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WEEKLY 17 February 2024

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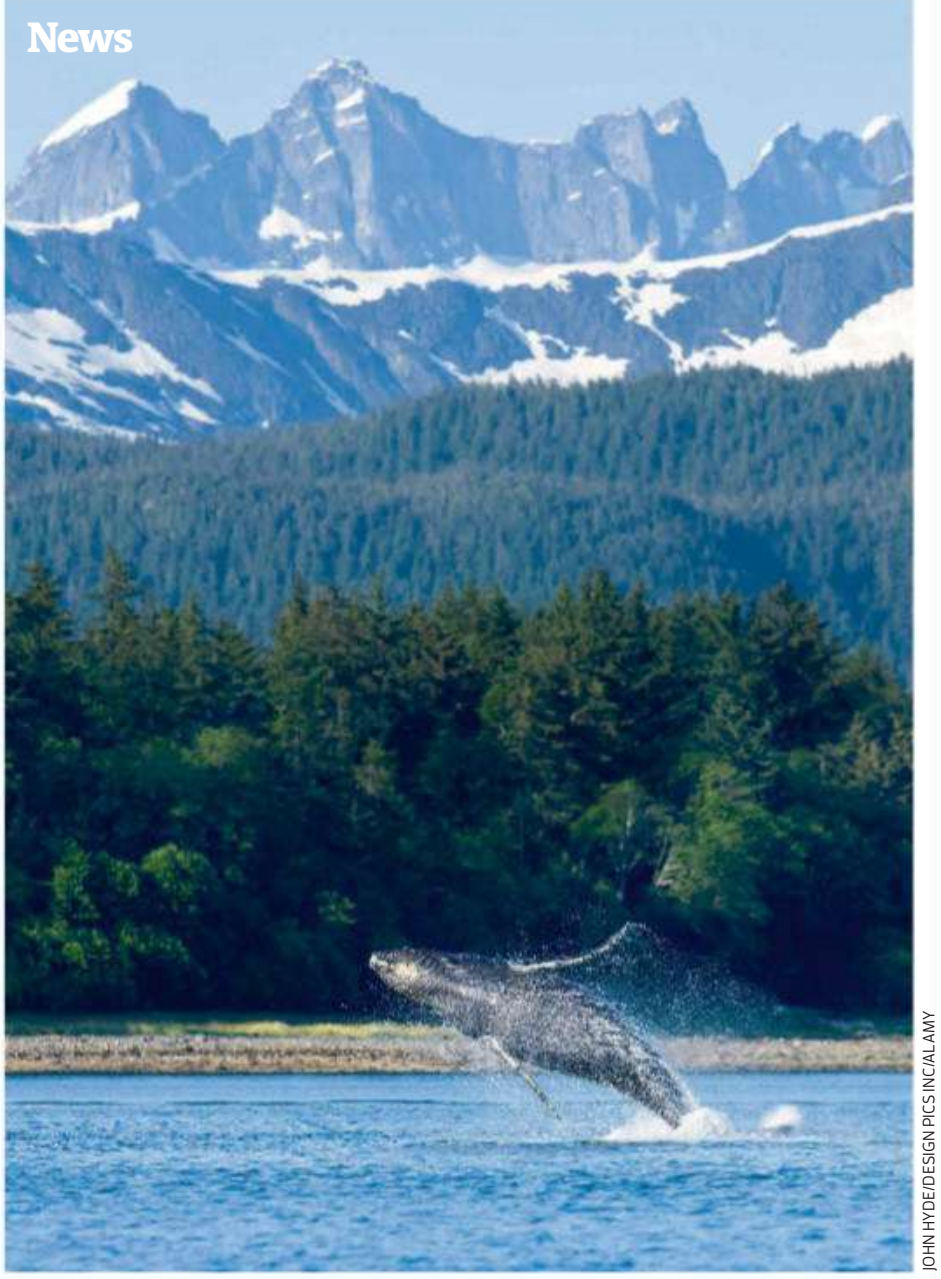


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# Elsewhere on New Scientist

## Online event

### The neuroscience of memory

The ability to store memories and relive each moment in detail makes a vital contribution to our lives. But remembering is about reconstruction rather than being a literal act of reproduction. In this free, subscriber-only online talk, neuroscientist Jon Simons will explore how the brain captures memories and how they are rebuilt when they are recalled. Join us on 4 June at 6pm BST.

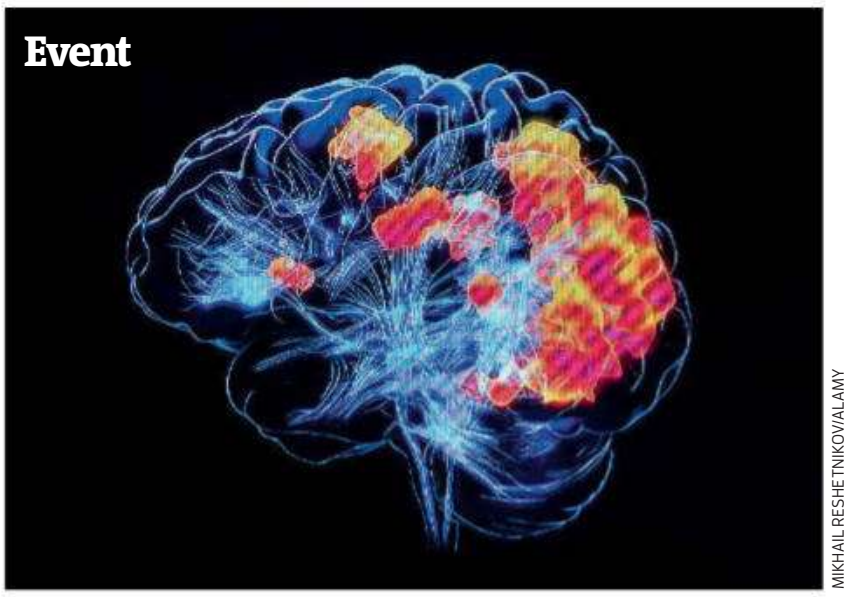
**newscientist.com/events**

## Tour

### Retracing Charles Darwin's travels: Wales

Discover the story of Charles Darwin's tours of Wales and retrace his travels on this trip to Eryri (Snowdonia) – scenery that has been transformed over hundreds of millions of years. Also taking in Darwin's birthplace, Shrewsbury, you will be joined by Darwin expert Michael Roberts and geologist Rob Knipe. This six-day tour begins on 13 May and costs £2995.

**newscientist.com/tours**




MIKHAIL RESHETNIKOV/ALAMY

**Total recall** How do our feelings affect how we make memories?

SHUTTERSTOCK/LUKASSEK

**Shaped by glaciers** Walk in Darwin's footsteps in north Wales

## Podcast

### Weekly

The team discuss how climate change may affect the fate of shipping in the Panama Canal. They also cover research on the relationship between microdosing LSD and brain complexity. Hear about fresh signs that asteroid Bennu came from an ocean world. Plus, there is a surprising Somalian lizard that looks a lot like a worm.

**newscientist.com/nspod**

## Video

### Artificial intelligence decodes ancient scroll

A papyrus scroll from the ancient Roman town of Herculaneum has been revealed using 3D mapping and artificial intelligence techniques. The new method can detect ink and decipher letter shapes even though the document was transformed into a lump of blackened carbon by volcanic ash from Mount Vesuvius in AD 79.

**youtube.com/newscientist**

## Newsletter

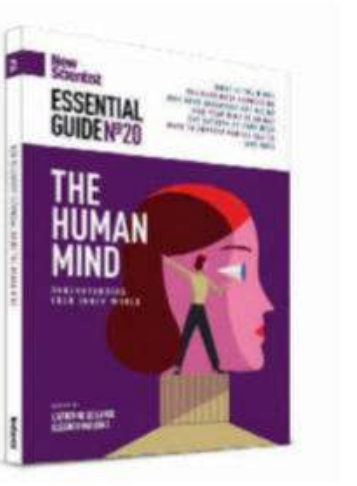
### Our Human Story

Michael Marshall considers which hominin remains should actually count as fossils. In the study of how organisms decay over time, called taphonomy, much depends on the precise conditions of temperature, pH and rock type. He finds that we perhaps shouldn't be using the word "fossil" so freely.

**newscientist.com/our-human-story**

## Podcast

**"How was this worm lizard found if it hadn't been seen for 90 years?"**




## Essential guide

Your mind underpins your every experience and is integral to both the internal feeling of being "you" and how others perceive you. It is so familiar, yet extremely hard to pin down. Unravel the truth about your inner world with the latest *New Scientist Essential Guide*. Buy it in print now.

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# Perpetual lunacy

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SCAN ME

# Hard to swallow

New archaeological evidence invites us to reassess our views on cannibalism

IT IS the ultimate taboo: in most societies, the idea of one human eating another is morally repugnant. Even in circumstances where it could arguably be justified, such as when a plane crashed in the Andes in 1972 and starving passengers ate the dead to survive, we still have a deep aversion to cannibalism. One of the survivors, Roberto Canessa, has since described the passengers' actions as a "descent towards our ultimate indignity".

Ethically, cannibalism poses fewer issues than you might imagine. If a body can be bequeathed with consent to medical science, why can't it be left to feed the hungry? Our aversion has been explained in various ways. Perhaps it is down to the fact that, in Western religious traditions, bodies are seen as the seat of the soul and have a whiff of the sacred. Or maybe it is culturally ingrained, with roots in early modern colonialism, when racist stereotypes of the cannibal were concocted to justify subjugation. These came to represent the "other" to Western societies – and revulsion towards cannibalism became a tenet of their moral conscience.

**"Understanding the roots of cannibalism might shift our view of the cultures that practise it"**

A slew of recent archaeological discoveries is now further complicating how we think about human cannibalism. Researchers have unearthed evidence suggesting that our hominin ancestors ate each other surprisingly often (see page 32). What's more, it seems that they weren't always doing so for the reasons you might expect – for sustenance or to compete against and intimidate rivals – but often as funerary rituals to honour their dead.

Like it or not, then, cannibalism is an important part of our story. This isn't to say that we should change our attitudes towards it. But understanding its deep roots might shift our perspective on the few cultures that still practise cannibalism today, albeit only occasionally, such as the Aghori, a Hindu ascetic sect in India that does it in pursuit of transcendence. Above all, these discoveries invite us to reconsider our revulsion to cannibalism in the context of our evolutionary past. ▮

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# News


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Earth

## Fire and ice from above

Lava erupted on the Reykjanes peninsula in Iceland on 8 February, for the third time since December 2023 (see page 12). This satellite view was captured by the Copernicus Sentinel-2 mission less than 10 hours after the eruption began. The evacuated coastal town of Grindavik can be seen at the bottom of the image.

EUROPEAN UNION/COPERNICUS SENTINEL-2 IMAGERY

Physics

# The Cheshire Cat's quantum twin

An experiment that could separate a particle's properties from its mass may shed light on the connection between gravity and quantum mechanics, reports **Alex Wilkins**

A NEW version of a strange experiment in which a particle's properties are separated from its body or mass, called the quantum Cheshire Cat, has physicists arguing over whether these disembodied properties are quite what they seem and how reality works in the quantum world.

In 2014, physicists experimentally demonstrated this strange effect – named after the Cheshire Cat from Lewis Carroll's *Alice's Adventures in Wonderland*, which can disappear leaving only its grin – by apparently detecting the presence of a neutron in one place while measuring one of its quantum properties, known as spin, in a separate location, divorced from the particle.

To do this, they forced a neutron to choose one of two paths along an instrument called an interferometer, measuring its properties at certain points along each path. Further measurements were recorded once the paths had merged again.

These measurements weren't made in the standard way that they are in most quantum experiments, which involves a particle collapsing from a cloud of possible values for each of its properties, like its position or its momentum, to each having a single value. Instead, the researchers made what are called weak measurements, which very faintly measure a particle without it collapsing.

A single weak measurement isn't enough to learn about a particle or its properties, but by repeating the experiment and measurements many times, and also measuring after the interferometer paths have merged again, you can theoretically glean information about what the particle was doing by running a statistical calculation.

AF FOTOGRAFIE/ALAMY

**The Cheshire Cat can disappear and leave behind its smile**

It was with this method that scientists first measured a neutron's spin on one side of an interferometer while the particle was detected on the other side. But in the decade since that experiment was first done, debates have raged about what weak measurements are really measuring and how they can be used. In the meantime, physicists have developed variations of the experiment that don't rely on specific systems like a neutron's spin.

Now, Mordecai Waegell, Jeff Tollaksen and Yakir Aharonov, all at Chapman University in California, have proposed a more general version of the Cheshire Cat experiment, in which a particle's mass is separated from its momentum (arXiv, doi.org/mgjq).

The experiment would be difficult to perform, but should be possible for almost any particle as long as it has mass, says Waegell. The major difference from other forms of the experiment is in how the particle's mass is detected, which involves having an extremely sensitive gravitational sensor. "It looks like we've separated the mass from the momentum of the particle," says Waegell. "How you interpret what's really going on, case by case, I think is still open to debate. But the effect is interesting, nevertheless."

**"It looks like we've separated the mass from the momentum of the particle"**

Waegell is "relatively agnostic" as to how to interpret such a counterintuitive outcome as a particle being separated from its momentum. But Aharonov, who was part of the team that originally came up with the quantum version of the Cheshire Cat, has an unusual idea that he calls the counter-particle view.

Rather than just one particle going down one of the paths, Aharonov suggests that a pair of particles, one the opposite of the other in every respect, can be conjured out of the quantum vacuum to travel down the paths, similar to virtual particles that are allowed by the laws of quantum mechanics and are used to explain a wide range of quantum phenomena.

## Particle annihilation

These particles annihilate in one of the arms, cancelling each other out and providing a reading of no mass, but because they travel different distances at different speeds, some momentum is left over to be measured.

This would be one possible explanation for such counterintuitive results, says Jonte Hance at Hiroshima University in Japan, but it is also possible to interpret the results of these experiments in other ways.

Hance and his colleagues have described the original quantum Cheshire Cat experiment using a hypothesis called quantum contextuality, which argues that the order and context of what you are measuring in a quantum system matters. "The measurements that you're doing in each of these cases have a kind of incompatibility, which is allowing you to get these paradoxical results," says Hance.

Regardless of what might be behind the quantum Cheshire Cat effect, testing out the mass and momentum version of the experiment could help us to learn about how gravity affects quantum mechanics, because it is a testable experiment that incorporates both concepts, says Hance. ▮

Archaeology

# Hominins may have left Africa 700,000 years earlier than we thought

Michael Marshall

OUR ancient ancestors may have ventured outside of Africa much earlier than previously believed, according to archaeologists working in Jordan. They say they have found stone tools there that were made and used 2.5 million years ago.

"Now we know that hominins left Africa at least 700,000 years before we thought," says Walter Neves at the University of São Paulo in Brazil.

Our lineage appears to have remained in Africa for millions of years after it emerged there about 7 million years ago. The oldest widely accepted evidence of hominins outside Africa is from Dmanisi in Georgia, where there are 1.8-million-year-old fossilised remains identified as *Homo erectus*.

Since 2013, Neves and his team have been excavating a rocky outcrop in the Upper Zarqa valley in Jordan. They focused on three rock layers. At the bottom is a layer of volcanic basalt, which their dating techniques show is 2.5 million years old. Above this is a layer of sediments laid down by a river, which contains the purported stone tools. Finally, on top is a layer of 1.95-million-year-old limestone. The researchers published these dates – based on three different methods – in a 2019 study, to little notice.

To firm up their case, they have re-examined the purported stone tools and described them in detail. The tools, they say, are a type called Oldowan that have been found at many locations in Africa, dating back as far as 3 million years ago (*Journal of Paleolithic Archaeology*, doi.org/mgh9).

The difficulty is that the researchers found these artefacts in what was once a fast-flowing river, says David Braun at the George Washington University in Washington DC. Some of the stones could have been reshaped to look like hominin-made tools simply by being bashed around in the water, he says. "That said, there are definitely objects in this collection that appear to be made through hard hammer percussion," says Braun.

FABIO PARENTI

**Upper Zarqa valley, Jordan, where purported stone tools (below) were found**

As such, he is persuaded that Neves and his colleagues really have made an important discovery. "My take on this is that there is very likely a hominin in Jordan making artefacts prior to 2 million years ago," says Braun. "I am uncertain exactly how much earlier than 2 million years ago."

Because some of the tools were found just above the basalt layer, Neves argues they are probably 2.5 million years old. This makes them older than any known fossils of *H. erectus*, implying that another hominin species was the first to leave Africa. Neves points to *Homo habilis*, which may have been present 2.3 million years ago or even earlier. "Our hypothesis is that the first hominin to have left Africa was *Homo habilis* and not *Homo erectus*," he says.

Other researchers have claimed to have evidence of hominins outside Africa older than the Dmanisi remains. However, none of these claims has been widely accepted. Either the artefacts themselves or their ages, or both, have been questioned. ▮

Space

## Power beamed from orbit in first proof-of-principle test

THE first experiment to transmit power to Earth from space could lead to a space-based solar power station within 10 years, according to one of the researchers involved.

Such a station would benefit from greater exposure to the sun, due to the lack of clouds and atmosphere along with the ability to avoid nighttime darkness. However, the difficulty of designing and making structures large enough to be useful but light enough to launch by rocket has made such a facility impractical.

In a step forward, Ali Hajimiri at the California Institute of Technology and his colleagues launched the Microwave Array Power Transfer LEO Experiment (MAPLE) to space in January 2023. Two months later, they successfully beamed the first power to Earth, after which they ran the experiment for a further eight months.

**"A system capable of beaming power for tens of thousands of homes would be around 1 km² in size"**

MAPLE consists of a lightweight array of microwave-producing chips that can direct a beam to a specified location, though it can't yet generate these microwaves from sunlight.

The team found that MAPLE could send 100 milliwatts of power through space and quickly refocus the beam to new locations. Over the course of the experiment, the team attempted to send power to Earth three times, receiving just 1 milliwatt on the ground each time (arXiv, doi.org/mgpb).

A fully functional system capable of transmitting 100 megawatts, enough to power tens of thousands of homes, would need to be around a square kilometre in size, compared with the 150 square centimetres or so of MAPLE.

"The size of the system is many orders of magnitude smaller than the system that you would need to use for a full-blown application, but the key part here is to have the technology demonstrated in space," says Hajimiri. ▮

Alex Wilkins

Animal behaviour

## Male cuttlefish burst through ink clouds to impress females

Jake Buehler

**SOME male cuttlefish squirt out ink to enhance courtship displays – the first evidence that the substance has uses beyond fighting and defence.**

**In the lab, Arata Nakayama at the University of Tokyo, Japan, and his colleagues recorded the behaviour of male and female Andrea cuttlefish (*Sepia andreana*) during courtship. Some males guided a female to the aquarium bottom and stroked her back and head, occasionally squirting ink above her. The team thinks the ink blobs may spook the female so she stays near the sandy bottom during a male's dance.**

**For his big finale, the male dispersed a larger cloud of ink and swam through it, like a stage performer emerging through theatrical fog. He then turned pale and iridescent, dramatically stretching his long arms and body, and pulsed dark bands of colour along one arm. All the males released ink in the same way, so the researchers believe it is a key part of courtship (*Ecology and Evolution*, doi.org/mgmc).**

**The diffuse ink cloud may act like mood lighting, darkening the area and obscuring the surroundings, which might visually magnify the male's flamboyant patterning and colouration, says Nakayama.**

**Roger Hanlon at the Marine Biological Laboratory in Woods Hole, Massachusetts, is particularly fascinated by how the males stroke the females, a highly unusual behaviour. "This touchy-feely thing, cephalopods don't do that," he says, except when they are fighting over food or mates, or touching briefly when guarding a mate.**

**"Birds have some of the most exotic and complex male courtship displays known in the animal kingdom," says Hanlon. "The courtship displays in this paper show comparable complexity, something that is generally not expected in invertebrate animals."** ▮

Physics

# What Einstein got wrong about ultra-speedy mirrors

Karmela Padavic-Callaghan

SHUTTERSTOCK/STOCK_GOOD

**Albert Einstein discovered a paradox in 1905**

A PARADOX that puzzled Albert Einstein may finally have been resolved. "If you search the internet for 'what would you see in a mirror moving at the speed of light?' you will find intense discussions on physics-related forums. Curiously enough, none of the proposed answers are correct," says Sergei Bulanov at the ELI Beamlines Facility in the Czech Republic.

Bulanov says that Einstein's calculations in 1905 showed that light reflected from a mirror moving at the speed of light would have infinite intensity and amplitude. But Einstein's special theory of relativity – the study of objects moving at the speed of light – suggested a different outcome: that any object moving at such high speed must turn transparent and reflect no light at all.

Bulanov and his colleague Timur Esirkepov at the National Institutes for Quantum and Radiological Science and Technology in Japan think they now have a way to resolve the paradox, finding that Einstein's idea of a mirror was unrealistically perfect.

It would take an infinite amount of energy to make a typical glass mirror move at the speed of light, so the researchers considered a more feasible alternative: mirrors made from plasmas, or mixtures of ions and electrons.

Such mirrors have already been produced in experiments using incredibly powerful lasers. When these lasers are directed at certain materials, they create plasmas containing localised disturbances that simultaneously reflect light like a mirror and move through the plasma extremely quickly, approaching the speed of light.

**"What would you see if you looked in a mirror moving at the speed of light?"**

Crucially, unlike the idealised mirrors Einstein considered, these real mirrors are three-dimensional – meaning there is plasma behind their reflective surfaces as well.

Bulanov and Esirkepov found that the properties of the 3D plasma mirror as a whole – and the properties of the light striking it – can vary. In some scenarios, this allows the light to be intensely reflected as Einstein predicted. But in others, the light is transmitted, and in yet more scenarios the light can form a wave whose peaks and valleys don't actually travel, oscillating near the mirror without going anywhere. The research will be published in *Physical Review E*.

Brendan Dromey at Queen's University Belfast in the UK says the new work is theoretical, but that it could be tested because of a recent boom in the number of facilities that use extremely strong lasers at the petawatt scale.

If plasma mirrors really can be made to reflect very intense light, they could lead to new imaging techniques, akin to more powerful X-rays, says Dromey. The intense light could also advance our understanding of fundamental physics by breaking seemingly empty space into the particle-antiparticle pairs that are thought to make it up, he says.

The assumptions that Bulanov and Esirkepov made about the 3D shape of the plasma mirror may still be a simplification, says Stefan Haessler at the Polytechnic Institute of Paris, but he finds the work valuable, as there are few mathematically exact studies of the situation.

Bulanov and Esirkepov are now planning to test their ideas at a high-powered laser facility in the Czech Republic. ▮

Mind

# Bilingual exposure counts early on

## Infants living in bilingual homes may have advantages when it comes to speech processing

**Moheb Costandi**

BABIES as young as 4 months old who are born into a bilingual environment show distinct and potentially advantageous brain patterns for speech processing.

Our early-life experiences influence our neural pathways and can have lifelong effects on our behaviour. The brain is most sensitive to its environment during the first year of life, which is thought to be a critical period for language development.

Previous studies have looked into the brain mechanisms that underlie speech processing in babies who hear just one language.

To better understand this in bilingual-exposed infants, Borja Blanco at the University of Cambridge and his colleagues compared how 31 babies who only heard Spanish and 26 babies who heard Spanish and Basque, all aged 4 months, responded to Spanish recordings of *The Little Prince* by Antoine de Saint-Exupéry.

The team used an imaging technique called functional near-infrared spectroscopy to measure changes in the babies' cerebral blood flow, indicating the areas of the brain being activated.

In the Spanish-only babies, the recordings elicited activity in areas of the left frontal and temporal lobes, which play a role in speech processing. In the bilingual-exposed babies, the recordings similarly evoked these responses, but they were larger and wider. These infants also had activation in the equivalent areas of their brains' right hemispheres (bioRxiv, doi.org/mgh3).

When the recordings were then played backwards as a control arm of the experiment, the infants exposed to just Spanish had larger responses to the backwards speech, while those exposed to Spanish and Basque had similar brain patterns as before. This may be because the bilingual infants take longer to register their primary language, in this case Spanish, as hearing both this and Basque reduces their overall exposure to either language.

**"A more diverse language environment leads to widespread and bilateral activation in the brain"**

If this is the case, it could help them be sensitive to linguistic differences and enable them to learn to differentiate between languages at a younger age. Utilising both sides of the brain for language may explain why left-handed people, who have more bilateral distribution for certain brain functions, often have better speech outcomes after a stroke.

Alternatively, infants exposed to only one language may find unfamiliar sounds more novel and so pay them more interest.

In their paper, the researchers say their study shows that a bilingual environment induces changes in the brain mechanisms underlying speech processing in young infants, adding weight to the idea that the neural basis of learning two or more languages is established very early in life.

"This tells us that left hemisphere lateralisation for language is the product of development and is influenced by language experience," says Evelyne Mercure at Goldsmiths, University of London. "A more diverse language environment that includes more than one language leads to widespread and bilateral activation." ▮

Technology

# Man feels warmth and cold through prosthetic arm

**A MAN who had his right arm amputated below the elbow has been able to feel hot and cold in his missing hand via a modified prosthetic arm with thermal sensors.**

**After an amputation, some people can still perceive touch and pain sensations in their missing arm or leg, known as a phantom limb. Sometimes, these sensations can be triggered by nerve endings in the residual upper limb.**

**The prosthetic works by applying heat or cold to the skin on the upper arm in specific locations that trigger a thermal sensation in the phantom hand.**

**"In a previous study, we have shown the existence of these spots in the majority of amputee patients that we have treated," says Solaiman Shokur at the Swiss Federal Institute of Technology in Lausanne.**

**First, Shokur and his colleagues mapped the spots on study participant Fabrizio Fidati's upper arm that trigger sensations in different parts of his phantom hand. Then they adapted his existing prosthetic hand and socket with sensors and devices that can be made hot or cold, called thermodes.**

**Tests showed that Fidati could identify bottles that were hot, cold or at ambient temperature with 100 per cent accuracy by touching them with his modified prosthetic. When the thermal sensor in the prosthetic was turned off, his accuracy dropped to a third.**

EPFL CAILLET

Fabrizio Fidati tests the temperature-sensitive prosthetic arm

**The prosthetic also allowed Fidati, when blindfolded, to successfully distinguish between glass, copper and plastic by touch with an accuracy just above two-thirds – the same as when using his uninjured left hand (*Med*, doi.org/mgh5).**

**Omid Kavehei at the University of Sydney, Australia, says the research could one day have applications beyond prosthetics, such as giving robots a greater range of physical sensations. "It's phenomenally important work," he says.** ▮

**James Woodford**

Conservation

# Migratory animals are in decline

Species that travel vast distances, from sharks to sea birds, face a bleak future

Chen Ly

HUNDREDS of migratory species – from humpback whales to wandering albatrosses – are under threat because of human activity, according to the first United Nations State of the World's Migratory Species report. The research found that almost half of the migratory animals on a UN list of vulnerable species are seeing population declines, while a quarter are at risk of extinction.

Billions of animals, belonging to more than 2000 species, travel vast distances every year for a variety of reasons, such as to find food or a place to breed. They include some of the world's most iconic animals, says Amy Fraenkel at the UN's Convention on the Conservation of Migratory Species of Wild Animals, such as whales, elephants, dolphins and turtles.

Such animals encounter a range of perils across their migratory routes, says Wolfgang Fiedler at the Max Planck Institute of Animal Behavior in Germany. "A stork can be endangered in central Europe by an electrocution risk that comes from wrongly built electricity pylons, in the Mediterranean region by environmental poisoning and habitat loss and in North Africa by illegal hunting."

In 1983, an international UN treaty came into effect that aimed to protect these animals. The Convention on Migratory Species (CMS) identified 1189 species as being of particular interest, partly because they regularly cross national borders. "These are species that really require international cooperation for their survival and conservation," says Fraenkel.

To understand how these migratory animals are faring today, Fraenkel and her colleagues conducted a comprehensive analysis of the conservation data for all the species.

Since 1990, 70 CMS-listed species have seen a rise in their risk of extinction. Significant population declines have hit 44 per cent of CMS-listed species, and 22 per cent are in danger

**The wandering albatross (*Diomedea exulans*) is at risk of extinction**

CHRIS & MONIQUE FALLOWS/NATURE PICTURE LIBRARY/ALAMY

of being wiped out entirely.

The team also identified a further 399 migratory animals – including many species of albatross – that are vulnerable to extinction, but aren't currently listed under the CMS. About half of these are fish species.

Human activity is the biggest factor behind these alarming trends. Overfishing, pollution and habitat loss from deforestation and urbanisation all put species at risk. Climate change is a problem too.

"But there are solutions to these challenges," says team member Kelly Malsch at the UN Environment Programme World Conservation Monitoring Centre, such as reducing light pollution or changing fishing gear to help reduce bycatch.

"To make the conservation of migratory species successful, most, if not all, of these threats need to be addressed at the right times at the right sites, during which large-scale coordination and collaboration is usually the key," says Tong Mu at Princeton University. ▮

Volcanology

## Magma flow in Iceland was the fastest ever seen

**THE flow of magma into a 15-kilometre-long crack ahead of the recent volcanic eruptions in Iceland occurred at the highest rate observed anywhere in the world for this kind of event.**

**"We can have higher rates in very large eruptions," says Freysteinn Sigmundsson at the University of Iceland in Reykjavik. "But I am not aware of higher estimates of magma flowing into a crack in the surface."**

**Sigmundsson is part of a team that has been using ground-based sensors and satellites to monitor recent volcanic activity under the Reykjanes peninsula in Iceland. This began with magma accumulating several kilometres beneath the Svartsengi region, the site of a geothermal power plant that supplies warm water to the Blue Lagoon spa, a tourist attraction.**

**On 10 November 2023, a massive crack several kilometres deep and 15 km long formed nearby. As it opened, some of the accumulated magma flowed up into it at a rate of 7400 cubic metres per second, the team has calculated (*Science*, doi.org/mghz).**

**That is around a hundred times faster than the magma flow that occurred during eruptions in 2021, 2022 and 2023 in the nearby Fagradalsfjall area of Iceland, says Sigmundsson.**

**The crack formed because the country is situated on a boundary where tectonic plates are moving apart. On 18 December, a so-called fissure eruption began along part of this feature, lasting three days. Another started on 14 January and spanned two days, with some of the lava reaching the evacuated town of Grindavik.**

**On 8 February, a third eruption began a little further away from Grindavik. The lava from this has flowed across the pipes carrying hot water from the Svartsengi geothermal plant. As a result, heating has been cut off in some nearby regions, as most buildings in Iceland rely on such facilities.** ▮

**7400**

Recorded rate of magma flow in cubic metres per second

Michael Le Page

Energy

# UK fusion reactor bows out with record-breaking run

Matthew Sparkes

THE UK's 40-year-old fusion reactor achieved a world record for energy output in its final runs before being shut down for good, researchers have announced.

The Joint European Torus (JET) in Oxfordshire began operating in 1983. When running, it was temporarily the hottest point in the solar system, reaching 150 million °C.

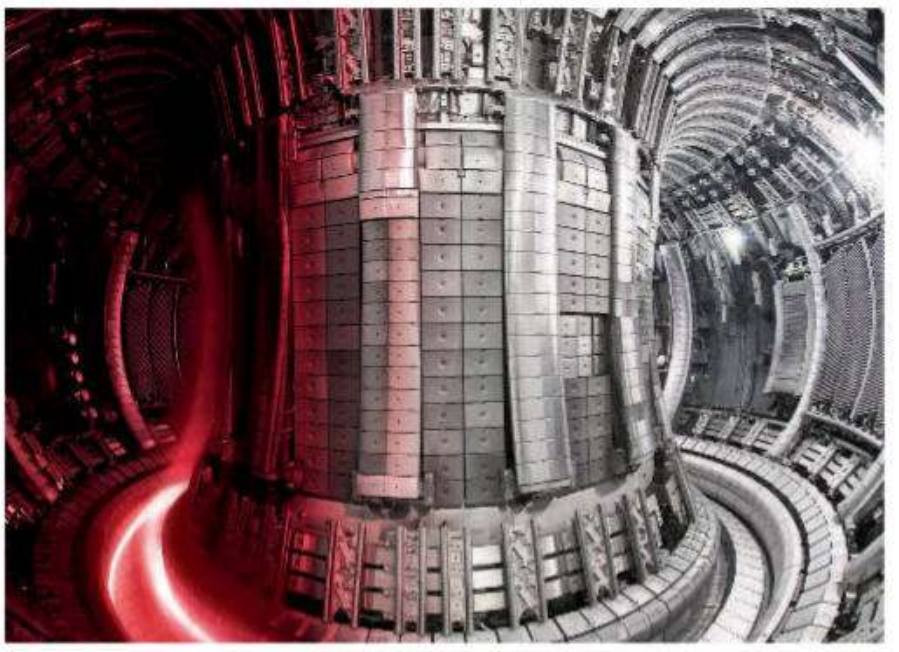
The reactor's previous record was a reaction lasting for 5 seconds in 2021, producing 59 megajoules of heat energy. But in its final tests in late 2023, it surpassed this by sustaining a reaction for 5.2 seconds while also reaching 69 megajoules of output, using just 0.2 milligrams of fuel.

This equates to an output of 12.5 megawatts – enough to power 12,000 homes, said Mikhail Maslov of the UK Atomic Energy Authority at a press conference on 8 February.

Today's nuclear power plants rely on fission reactions, where atoms are smashed apart to release energy and smaller particles. Fusion works in reverse, squeezing smaller particles together into larger atoms.

Fusion can produce more energy without the radioactive waste created as a result of fission, but we don't yet have a way to harness this process for practical uses.

JET forged together atoms of deuterium and tritium – two stable isotopes of hydrogen – in plasma to create helium, while also releasing a vast amount of energy. This is the same reaction that powers our sun. It was a type of fusion reactor known as a tokamak, which contains plasma in a doughnut shape using rings of electromagnets.



EUROFUSION

**The JET reactor confines plasma in a ring shape**

Scientists ran the last experiments with deuterium-tritium fuel at JET in October last year and other experiments continued until December. But the machine has now been shut down for good and it is being decommissioned over the next 16 years.

Juan Matthews at the University of Manchester, UK, says JET will reveal many secrets as it is dismantled, such as how the lining of the reactor deteriorated through contact with plasma and where valuable tritium – worth around £30,000 a gram – has embedded in the machinery and can be recovered. This will be vital information for future research and commercial reactors.

**69**

**Megajoules of energy released by the JET reactor in its best-ever test**

"It's great that it's gone out with a little flourish," says Matthews. "It's got a noble history. It's served its time and they're going to squeeze a bit more information out of it during its decommissioning period as well. So it's not something to be sad about; it's something to be celebrated."

A larger and more modern replacement for JET, the International Thermonuclear Experimental Reactor (ITER) in France, is nearing completion, and its first experiments are due to start in 2025.

Tim Luce, deputy head of the construction project, told the press conference that ITER will scale up the energy output to 500 megawatts, or possibly even 700."These are what I usually call power-plant scale," he said. "They're at the lower end of what you would need for an electricity-generating facility.

"In addition, we need to extend the timescale to at least 300 seconds for the high fusion power and gain, but perhaps as long as an hour in terms of energy production. So what JET has done is exactly a scale model of what we have to do in the ITER project." ▮

Technology

# Video games could help put adaptable AI to the test

**PLAYING *Minecraft* could be key to creating adaptable artificial intelligence models that can pick up a variety of tasks the way humans do.**

**Steven James at the University of the Witwatersrand in South Africa and his colleagues developed a benchmark test within *Minecraft* to measure the general intelligence of AI models. This MinePlanner test rates an AI's ability to ignore unimportant details while solving a complex, multi-step problem.**

**Lots of AI training "cheats" by giving a model all the data it needs to learn how to do a job and nothing extraneous, says James. Future AI models will need to tackle messy problems, and he hopes that MinePlanner will guide that research. AI working to solve a problem in the game will see the landscape, extraneous objects and other detail that isn't necessarily needed to solve a problem and must be ignored. It will have to survey its surroundings and work out by itself what is and isn't needed.**

**The virtual test consists of 15 construction problems, each with an easy, medium and hard setting. To complete each task, the AI may need to take intermediate steps – building a set of stairs in order to place blocks at a certain height, for instance. That demands that the AI can zoom out of the problem and plan ahead.**

**State-of-the-art planning AI models were unable to complete any of the hard problems and fared only slightly better with the easy and medium ones, suggesting there is room for improvement (arXiv, doi.org/mghx).**

**"We can't require a human designer to come in and tell the AI exactly what it should and shouldn't care about for each and every task it might have to solve," says James. "That's the problem we're trying to address."** ▮ **MS**

Analysis Coronavirus recovery

# Exercising can help people with long covid – at least a bit

An eight-week exercise programme modestly improved the quality of life of people with long covid, but it may not benefit everyone with the condition, finds **Clare Wilson**

FOR the first time, an exercise-based rehabilitation programme has been found to improve the health of people with long covid.

It might seem like this would be universally welcomed. But it could reopen the long-standing dispute over whether people with post-viral fatigue conditions should be encouraged to build up their exercise levels or whether this risks setting them back further.

Long covid is a term used to describe lasting symptoms after a covid-19 infection, with the most common ones including fatigue, breathlessness and difficulties concentrating. It is unclear exactly what causes it, how likely it is to occur after the infection and how best to treat it.

While there are no specific treatments, doctors tend to recommend generic strategies for improving symptoms. For any form of post-viral fatigue, this generally means trying to build back strength by slowly increasing activity levels.

That brings conflict with ideas about myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS), another poorly understood long-term health problem, which is possibly sometimes triggered by a viral infection.

## Building up activity

Until recently, the main treatments in the UK for ME/CFS were rehabilitation programmes combined with talking therapy, but these are unpopular with some patient activists, who say they imply the condition is all in the mind.

Campaigners also say that encouraging people to raise their exercise levels can trigger post-exertional fatigue, something that can also be experienced by those with long covid.

In the new study, which involved 585 people with long covid, Gordon McGregor at University Hospitals Coventry in the UK and his colleagues investigated a similar approach that involved gradually increasing exercise levels alongside talking therapy. But there were crucial differences compared with the regimes that have earned the ire of some ME/CFS groups.

In the old ME/CFS approach, called graded exercise therapy, people may be asked to raise their exercise levels by a certain amount every week, which some find too onerous. In McGregor's trial, people didn't have to stick to a rigid schedule of increasing their exercise levels according to a certain timescale, but could tailor the intensity up or down as needed.

The team offered half the participants online rehab sessions once a week for eight weeks in groups of up to eight people. A control group just had one online advice session about a self-directed exercise programme.

Those who got the eight weeks of rehab had significant improvements in a score for health-related quality of life – which assessed how they were affected by factors such as pain, fatigue and depression – compared with the control group. After three months, 50 per cent felt at least somewhat better, compared with 30 per cent of those who only got the advice session. And 17 per cent said their overall health was "much better", compared with 8 per cent in the control group (*The BMJ*, doi.org/mgcc).

**585**
**Number of people in a study testing exercise for long covid**

**50%**
**Proportion of trialists who felt somewhat better after rehab**

**17%**
**Proportion of participants who felt much better after rehab**

REUTERS/JENNIFER LORENZINI

**Exercising in pools is used by some to help recovery from long covid**

In addition, only one person had a severe adverse event that might have been related to the treatment, when they fainted and vomited the day after a rehab exercise session.

One caveat, however, is that all the people in the trial had an initial covid-19 infection so severe that they had been treated in hospital, with about a third spending time in intensive care or high-dependency units. Many people who have long-lasting symptoms after covid-19 initially had a milder illness. The causes of their lasting symptoms are less clear and might be different to those who needed hospital treatment, possibly for weeks or even months, who may have had muscle wasting and organ damage.

As a result, we can't necessarily conclude from these results that non-hospitalised people with long covid would also benefit from this rehab programme, says Jo House at Long Covid Support, a UK charity.

Also, only about half of the people who were offered the rehab attended most of the sessions, which might indicate that those who dropped out couldn't tolerate the exercise, she says. Putting these facts aside, it is also disappointing that the success rate wasn't higher, says House. On the other hand, it is the first time a randomised trial – the best type of medical evidence – has shown anything to have even a modest benefit for this condition. That should surely be a cause for cautious celebration. ▮

Space

# SpaceX aims to stop comms blackouts

A trick with satellites could let spacecraft re-enter Earth's atmosphere without losing radio contact

Mark Harris

SPACEX is about to test a system aimed at overcoming the communications blackout spacecraft go through when they re-enter Earth's atmosphere.

Almost every vehicle that has returned to Earth has suffered a break in communications during re-entry as the atmosphere slows it down. The same friction that decelerates the craft also heats the air below it until this ionises into a glowing, conductive plasma. This forms a sheath around the spaceship that blocks radio frequency signals to Earth.

Blackouts last several minutes, during which the fate of any people on board is unknown. Astronauts leaving the International Space Station on SpaceX's Crew Dragon capsule can lose communications for 7 minutes.

The problem isn't limited to spacecraft. Any vehicle going at speeds above Mach 5 will have similar issues, including hypersonic missiles. Radio blackouts could complicate their guidance and abort functions.

ESA–D. DUCROS, 2014

**Capsules entering Earth's atmosphere get surrounded by hot plasma**

**"Instead of trying to punch signals through hot plasma, SpaceX will send them up to satellites"**

Now, SpaceX thinks it might have a solution. Instead of trying to punch communication signals through hot plasma down to the ground, it will send signals up to its orbiting satellites instead.

Sometime in the next few months, one of the firm's 70-metre-tall Falcon 9 rockets will blast off from Cape Canaveral in Florida with a Starlink system on its second stage. This won't be another SpaceX satellite to join the approximately 5300 it already has in orbit, but a standard user terminal to access them.

According to a document filed with the US Federal Communications Commission, the experiment will start once the Falcon 9 deploys its commercial payload and will run until the second stage burns up on re-entry.

The success of a similar idea for NASA's 37-metre-long space shuttle hints the technique could work for SpaceX, at least in some situations. From the late 1980s, the space shuttle avoided re-entry blackouts by connecting to a NASA satellite.

But that satellite was in a distant geostationary orbit, so seemed fixed in the sky because its orbital velocity matched Earth's speed of rotation. The Starlink satellites are in much closer low-Earth orbits, where their orbital velocity whips them across the sky in minutes. This means the Falcon system will have to switch from one satellite to another in quick succession.

Even if the experiment works on the Falcon rocket, it may not translate to the smaller Crew Dragon capsule, which is only about 8 metres long, says Richard Ziolkowski at the University of Arizona. "Plasmas are notoriously fickle in the sense that if you have a little change in shape, you get pretty large changes in the plasma."

SpaceX hasn't responded to a request for comment. ▮

Energy and fuels

## Huge deposit of hydrogen gas found deep below Albania

**THE largest flow of natural hydrogen gas ever seen has been measured deep in an Albanian mine. It could help us work out where to find deposits of this clean fuel.**

**"The bubbling is really, really intense," says Laurent Truche at the University of Grenoble Alpes in France, who measured the gas in a pool of water nearly a kilometre underground. "It's like a Jacuzzi."**

**Companies are searching worldwide for deposits of natural hydrogen as a source of clean fuel, but data on large accumulations is sparse. Most claims about vast deposits rely on extrapolation, rather than direct measurements.**

**So, Truche and his colleagues descended into the Bulqizë chromite mine in Albania, where hydrogen gas seeping out of the rocks has caused several explosions. The mine is located within an exposure of iron-rich rock, known as an ophiolite. Water is known to react with such rock to generate hydrogen in other places, such as Oman.**

**The researchers found that the gas bubbling from the pool was more than 80 per cent hydrogen, with methane and a small amount of nitrogen mixed in. It was flowing**

F-V. DONZÉ

The Bulqizë chromite mine in Albania, where hydrogen seeps up through the rock

**at a rate of 11 tonnes per year, almost an order of magnitude greater than any other flow of hydrogen gas measured from a single point on Earth.**

**The researchers modelled geological scenarios that could produce such a flow and found the most likely was that the gas was coming from a deeper reservoir of hydrogen accumulated in a fault beneath the mine. Based on the fault's geometry, they estimate the reservoir contains at least 5000 to 50,000 tonnes of hydrogen (*Science*, doi.org/mgbs).**

**The find supports the idea that much more hydrogen is stored underground, says Geoffrey Ellis at the US Geological Survey. "We really should be looking deeper."** ▮

James Dinneen

Analysis Dementia protection

## Does Viagra help to protect against Alzheimer's? A study has found a link between taking erectile dysfunction drugs and a lower risk of developing Alzheimer's disease, but it is far from definitive, finds Clare Wilson

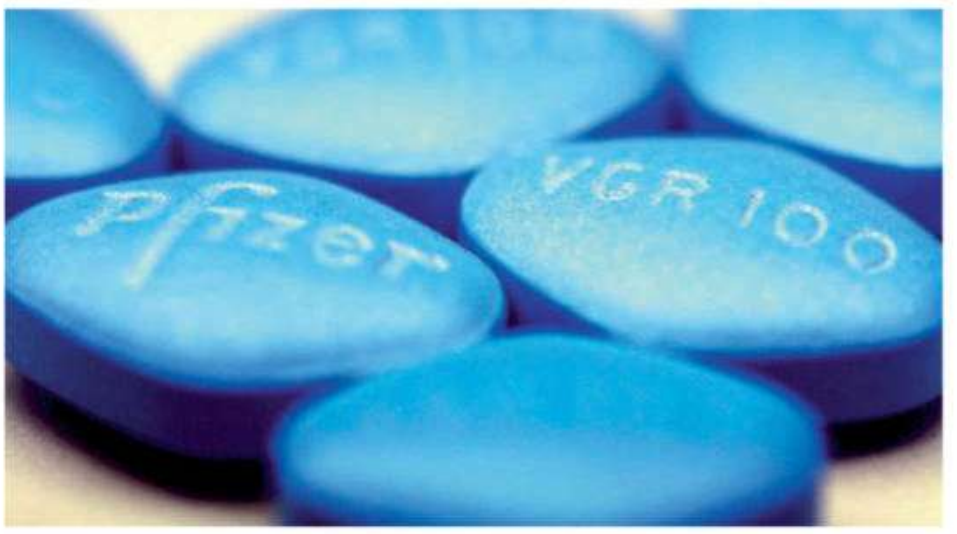
ANYONE considering using Viagra as a treatment for impotence could be forgiven for thinking there is now another reason to go ahead with it. Some news headlines say that this class of drugs, known as PDE5 inhibitors, protects people from developing Alzheimer's disease.

It sounds too good to be true – and, sadly, such claims are probably premature.

The stories are based on a study by Ruth Brauer at University College London and her colleagues. They looked at anonymised medical records of nearly 270,000 men in the UK aged 40 or older who had a new impotence diagnosis.

Those who went on to get prescriptions for Viagra (sildenafil) or a similar drug had an 18 per cent lower chance of being diagnosed with Alzheimer's over the next five years (*Neurology*, doi.org/mf8v).

It isn't implausible that this class of drug could protect against dementia. These therapies are being investigated for several conditions, including to help protect babies from oxygen deprivation during childbirth, and Viagra was originally developed as a treatment for heart disease.



ALFRED PASIEKA/SCIENCE PHOTO LIBRARY

**Viagra is used for erectile dysfunction, but might be able to help with other conditions**

The drugs work by raising levels of a signalling molecule called cGMP that dilates blood vessels and so boosts blood flow to the penis. Animal research has shown that the drugs also dilate blood vessels to the brain, which may keep it in better shape.

A second potential mechanism is that they raise levels of a nerve signalling molecule called acetylcholine, which could help brain cells communicate with each other. Indeed, some existing medicines that slightly alleviate dementia symptoms work by boosting acetylcholine.

But we need to be careful about drawing conclusions from this kind of study. It wasn't a randomised trial, where, for instance, hundreds of men would be given either Viagra or placebo pills and their subsequent rates of Alzheimer's compared.

Instead, the findings come from an observational study, where scientists use records to observe patterns of behaviour, such as using Viagra or not, to see if that correlates with health outcomes.

This type of study is prone to bias because a third factor could be linked with Viagra use and be protective against Alzheimer's disease. It is why scientists often say "correlation doesn't prove causation".

Bauer's team adjusted their results for several possible confounding factors, including age and many health aspects. But they couldn't take account of the men's physical activity levels, as this wasn't listed in their medical records. It is plausible that men who sought prescriptions for impotence pills were also more physically active and it was this that guarded against dementia. "We know that activity protects against Alzheimer's disease," says Bauer.

The latest results aren't, therefore, a reason to see these drugs as a silver bullet for preventing dementia, with the added bonus of treating erectile dysfunction. "Our study can't say for sure it's the drugs that are responsible for the protective effect," says Bauer. They may, however, be a stimulus for carrying out randomised trials in the hope this will provide firmer evidence. ▮

Biotechnology

## Cyborg locusts could sniff out bombs thanks to nano boost

**LOCUSTS with nanoparticles injected into their brains might one day be used as cyborg detectors for explosives or environmental contaminants.**

**Researchers have previously sought to utilise locusts' powerful sense of smell by placing electrodes in their brains and recording the signals that occur when they sniff certain chemicals. However, the accuracy of these systems isn't always reliable because each locust will have a slightly different electrode placement in its brain, so the recorded neural activity will also differ slightly each time.**

**Now, Srikanth Singamaneni at Washington University in St Louis, Missouri, and his colleagues have boosted the accuracy of this technique, using nanoparticles that can be heated with beams of infrared light. Once injected into the locusts' brains and illuminated with a laser, the nanoparticles amplify the neural activity in response to smells (*Nature Nanotechnology*, doi.org/mf79).**

**"There is an increase in the neural activity that is occurring in response to an odour stimulus"**

**"There is a significant increase in the neural activity that is occurring in response to an odour stimulus," says Singamaneni. This made it easier for the researchers to differentiate odours when they tested locusts on common chemicals.**

**The nanoparticles are made from a protein core and a silicon shell. They can have chemicals loaded onto the exterior that are released when they are exposed to light.**

**Singamaneni and his team loaded the nanoparticles with a neurotransmitter called octopamine, which has been linked to the "fight or flight" response in insects, and found this improved smell discrimination even further.**

**The effect could be deployed in other medical applications that require localised heating, says Bill Hansson at the Max Planck Institute for Chemical Ecology in Jena, Germany.**

**Singamaneni and his team hope that such modification of the locusts' neural activity might eventually lead to a fully functional cyborg smell detector, but they still need to demonstrate the system working in real time, he says.** ▮

**Alex Wilkins**

Mind

## Locations stick in our memories better than other details

Suhanee Mitragotri

**OUR memory for the who, what and why of a situation appears to fade over time, but we may be better at remembering the where of it.**

**To investigate how memories change, Wilma Bainbridge at the University of Chicago and her colleagues did two experiments. In the first, 1609 people were shown images of six scenes – a bedroom, kitchen, living room, amusement park, garden and public park – for varying lengths of time, from 100 milliseconds to 10 seconds.**

**Immediately after seeing the images, the participants had to recreate them in as much detail as possible by drawing what they had been shown using a computer mouse or trackpad.**

**In the second experiment, the researchers showed 942 people the same scenes, all for 10 seconds. Some were asked to draw these immediately, while others did so 5 minutes, 1 hour, one day, two days or one to two weeks later.**

**Participants included fewer of the objects, such as a bed or tree, in their drawn scenes if they looked at the image for less time or had to wait longer to draw. About one-fifth of those who waited for two weeks drew at least one object that wasn't in the original scene, and three-quarters of drawings contained more than one false object.**

**Although the participants didn't remember all the objects in scenes, of those that they did remember, they could correctly locate them in the images (bioRxiv, doi.org/mf76). Team member Emma Megla says "there might just be something special about spatial memory" that makes it different from how we remember other things.**

**This may be important for eyewitness testimonies, says Megla. Perhaps details a witness gives about the location of a person or object are more accurate than those about appearance, she says.** ▮

Technology

# Time crystals could keep quantum computers stable

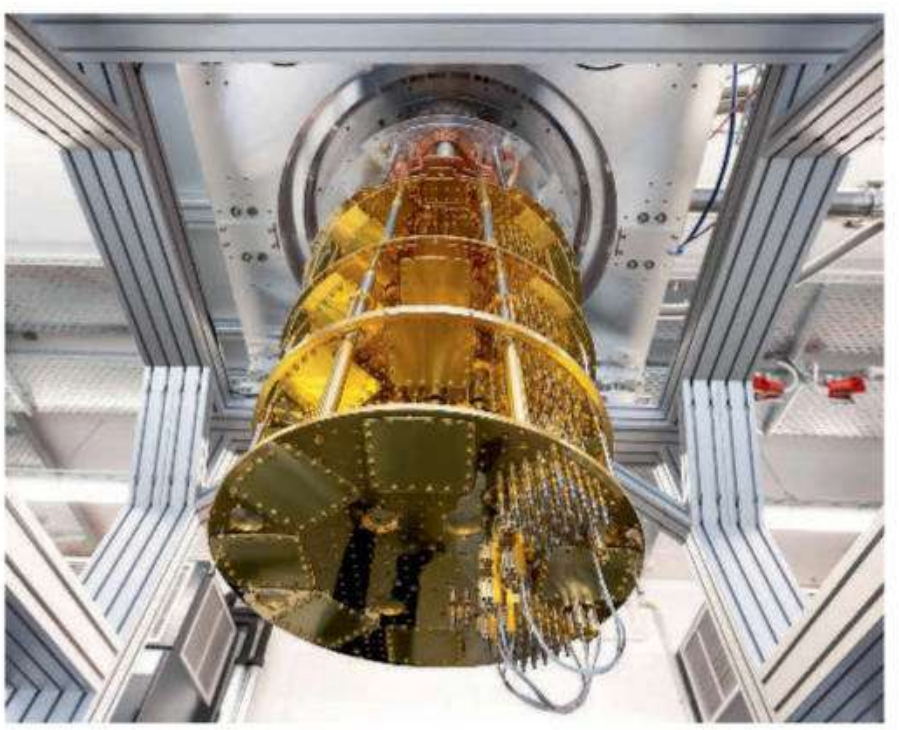
Karmela Padavic-Callaghan

BY ACTING as a control knob, a strange state of matter called a time crystal can stabilise fragile states within quantum computers, which could one day give them an edge over traditional computers.

Nobel laureate Frank Wilczek first theorised that time crystals exist in 2012. Their defining characteristic is that they flip between two configurations forever without any energy input – a seeming violation of the laws of physics. But several research groups have since created time crystals in the lab.

Now, Biao Huang at the University of Chinese Academy of Sciences and his colleagues have created a kind of control knob for a quantum computer using what is known as a discrete time crystal, a configuration that oscillates following a pattern in time – this is analogous to the patterned arrangement of atoms in crystals such as table salt.

**Quantum computers are very sensitive to disturbances**



SVEN HOPPE/DPA/ALAMY

The qubits in this quantum computer are made from tiny circuits that perfectly conduct electricity and can be controlled with microwaves. Unlike in conventional computers where bits either have a value of 1 or 0, the qubits' quantum states allow them to be equivalent to 1 and 0 simultaneously.

The researchers put the qubits into a special state called the Greenberger-Horne-Zeilinger (GHZ) state, in which they are all linked through quantum entanglement.

Past experiments show that the more qubits that comprise the GHZ state, the more fragile it gets, becoming increasingly easy for its entangled state to be destroyed by small disturbances in the quantum computer.

But the researchers were able to increase their control over the quantum computer and minimise disturbances in their device to make a record-breaking GHZ state that included 60 qubits – 28 more than the previously largest.

To make the same kind of state last longer, the researchers turned to the discrete time crystal.

They hit the qubits with a specific sequence of microwaves, each of which changed qubits' states or made them interact. The microwave pulses also put these qubits in the right states for their quantum properties to oscillate in time and form a time crystal (arXiv, doi.org/mf65).

**"We used the time crystal to construct a 'safe house' for sheltering the fragile quantum states"**

"We used the structure of the discrete time crystal to construct a 'safe house' for sheltering the fragile GHZ states," says Huang. "As far as we know, this is the first practical application of a discrete time crystal. Our work tells people that time crystals are not only conceptually interesting but also have practical value."

The sequences of microwave pulses that the team used introduced some imperfections, so the experiment where the GHZ state was housed in a time crystal involved 36 qubits rather than 60. Yet Huang says the state was less fragile than before, because it lasted longer.

The oscillation of the time crystal screens out disturbances that would normally make the GHZ state collapse, says Francisco Machado at Harvard University.

Being able to make very large GHZ states would boost our understanding of how quantum effects diminish for bigger objects. It would also help make more stable quantum computing and communication applications, says Huang. ▮

Health

# How periods change with age

## Menopause has a strong effect on the variability of the menstrual cycle

**Elizabeth Hlavinka**

THE menopause and the time leading up to it can particularly alter menstrual cycle patterns.

It was known that the menstrual cycle can change with age, but to get a clearer picture of how, Adam Cunningham at the period tracker app Flo in London and his colleagues have analysed data that was self-reported by 19 million app users, aged between 18 and 55, from 2022 to 2023.

Overall, the team found that cycles became shorter and more variable as people aged. An exception was between the ages of 47 and 55, when the length increases sharply, as well as getting more variable.

Irregular cycles – defined as having various points in the year where the shortest and longest cycles differed by more than a week – were most frequent among 51 to 55-year-olds, but least common in those aged 36 to 40 (medRxiv, doi.org/mf6n).

People of all ages commonly reported symptoms during a period including cramps, breast tenderness and fatigue, as well as bloating and mood changes. Headaches were common among those aged 46 to 55.

PIXDELUXE/GETTY IMAGES

In the UK and the US, the average age when the menopause starts is 51, but perimenopause – the transition to menopause when oestrogen levels start to fluctuate – often begins in the early 40s and can be accompanied by changes to the menstrual cycle and its effects.

Knowledge of the menstrual cycle during the perimenopause and menopause is "really at a minimal level", says Christine Metz at healthcare provider Northwell Health in New York. "People don't know what to expect in menopause, so I think this could relieve some of their concerns."

A 2022 survey by the UK's Department of Health and Social Care reported that fewer than 10 per cent of women said they had received enough information on the menopause, with "menstrual health" being a key concern.

**Age does change the menstrual cycle, but not necessarily in a set way**

"Understanding these age-related differences in cycle characteristics and symptoms is important in understanding how best to care for and improve daily experience for menstruators," say the researchers.

Although the study is big, Metz says nearly half of the respondents fell into the 18-to-25 age category, with the number of app users declining in older age groups, so it isn't equally representative of all groups. Using self-reported data also runs the risk that users forgot to input information or recorded it inaccurately. When they forgot to record their last bleeding day, the team assigned a bleeding length of five days for that period.

Metz also points out that the data wasn't broken down by ethnicity or whether participants had conditions like endometriosis or polycystic ovary syndrome, which can affect periods. ▮

Technology

# Old milk provides a whey to extract gold from e-waste

**AN AEROGEL made from old milk can extract gold nuggets from old computer motherboards.**

**Discarded electronics, known as e-waste, often contain gold and other heavy metals. There are methods to recover the valuable metals, but these processes often rely on synthetic chemicals that can damage the environment.**

**Now, Raffaele Mezzenga at ETH Zurich in Switzerland and his colleagues have found a way to recover gold from e-waste by using a milk-derived aerogel, a type of gel where the liquid component is replaced with gas. "If you do an economic calculation, the margin is quite high because we start from a material [e-waste] which has no cost, and we start from a material [whey] which is very easy to process," says Mezzenga.**

**Mezzenga and his team took discarded whey, a by-product of strained milk, and extracted long, nanoscopically thin protein fibres. They then added an acid to link the fibres, froze them and heated the resulting mass to form an aerogel.**

**Next, they placed the aerogel in a soup of computer motherboards, which they had stripped of all non-metal parts and then dissolved in a combination of hydrochloric and nitric acid. They found that the aerogel absorbed gold ions from the liquidised e-waste. After drying and burning the aerogel scaffolding, Mezzenga and his team recovered gold nuggets of more than 90 per cent purity, equivalent to 22 carats, with most of the remainder of each nugget being copper (*Advanced Materials*, doi.org/mf6m).**

RAFFAELE MEZZENGA

A gold nugget obtained by processing melted-down old computer motherboards

**Using one waste product to extract valuable material from another is sustainable, but as the aerogel also absorbs other metals, it makes the gold less widely usable, says Jason Love at the University of Edinburgh, UK. He adds that people shouldn't try the method at home because dissolving motherboards in acid is dangerous and can give off toxic fumes.** ▮

**Alex Wilkins**

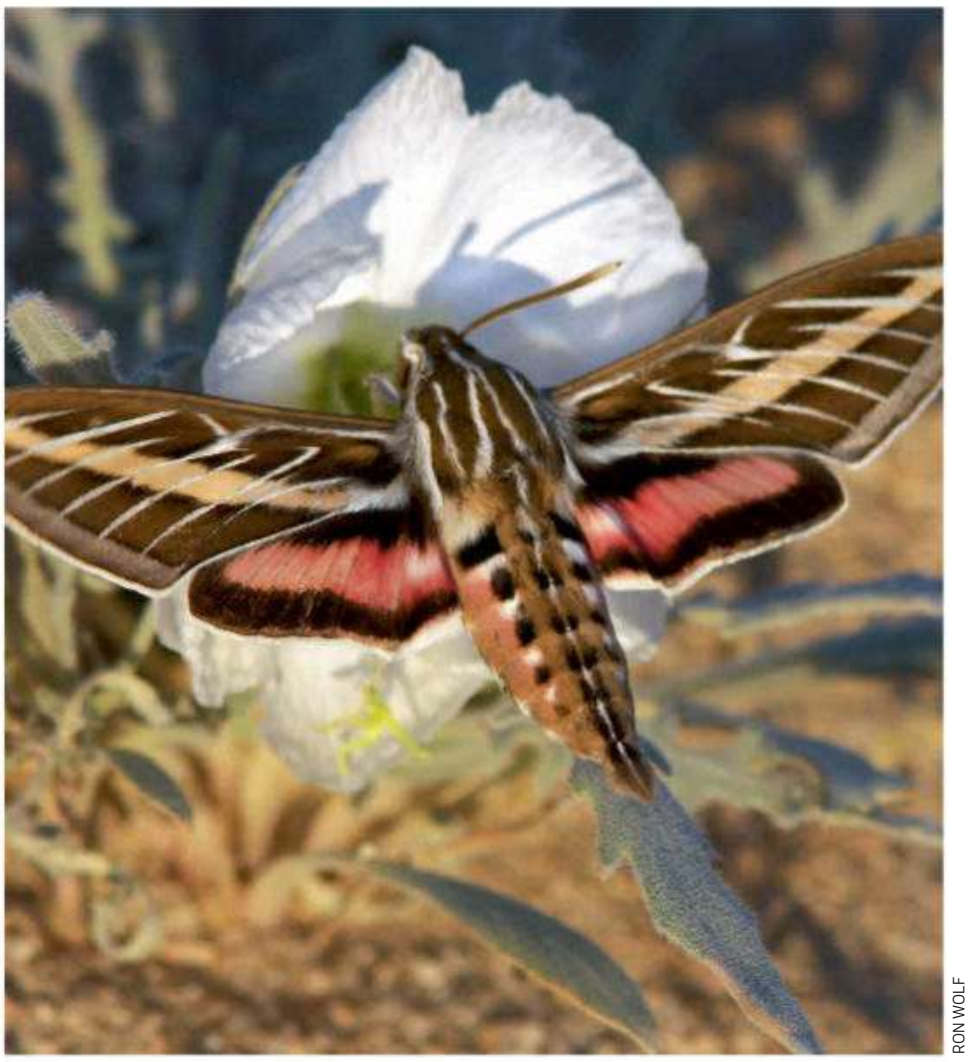
Space

## Exoplanets may have magma seas

A TYPE of exoplanet thought to host liquid water oceans may instead be covered in magma seas.

Oliver Shorttle at the University of Cambridge and his colleagues have studied James Webb Space Telescope (JWST) data on the exoplanet K2-18b. This world is typically hycean – a name given to planets with a hydrogen-rich atmosphere above a liquid ocean. Such planets are prime targets in the hunt for alien life.

However, recent models of K2-18b's climate indicate that it may be hotter than we thought, and water would have boiled away. The researchers say magma oceans match the JWST observations as well as water oceans (*The Astrophysical Journal Letters*, doi.org/mf8q). The finding may make detecting habitable conditions on hycean planets harder. **Leah Crane**



RON WOLF

Medicine

## Nanoparticles may treat lung disease

INHALING antibiotic-filled nanoparticles could help treat chronic obstructive pulmonary disease (COPD).

Junliang Zhu at Soochow University in China and his colleagues made nanoparticles from silica, giving them a negative charge to help them penetrate mucus. The team filled the nanoparticles with the antibiotic ceftazidime and put them in an inhalable spray to treat a bacterial lung infection in six mice with signs of COPD.

Mice treated with nanoparticles had about 98 per cent less pathogenic bacteria in their lungs than mice that received only the antibiotic. They also had fewer inflammatory molecules in their lungs and less carbon dioxide in their blood, implying better lung function (*Science Advances*, doi.org/mf8r). **Grace Wade**

Environment

## Pollution can make flowers less attractive to insects

**INSECTS may be struggling to locate flowers because air pollutants are degrading the chemical compounds responsible for their enticing floral scents.**

**Jeff Riffell at the University of Washington in Seattle and his colleagues have investigated the effects of ozone and nitrate radicals, pollutants created by the interaction of vehicle emissions with gases in the atmosphere. Both are known to react with compounds given off by flowers, altering their smell.**

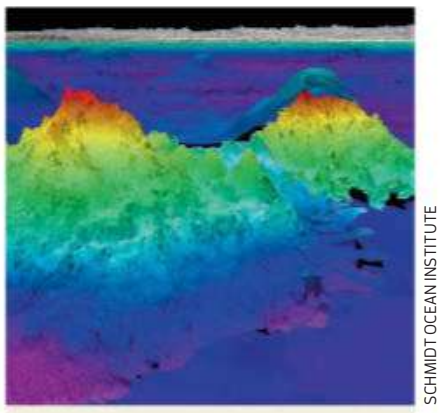
**The team collected the compounds released by the pale evening-primrose (*Oenothera pallida*), a desert flower found in North America. Both pollutants broke down the scent compounds, but nitrate radicals did so more completely.**

**To see if this changed the behaviour of the flowers' primary pollinators, the researchers exposed hawk moth species, including the white-lined sphinx (*Hyles lineata*, pictured above), to flowers that either emitted the natural flower scent or had been manipulated to release a degraded scent.**

**The primroses that released the degraded scents were visited 70 per cent less frequently than the flowers releasing natural scent (*Science*, doi.org/mf8p). This drop in visitation could affect hawk moth health, says Riffell. It could also have a knock-on effect on the wider ecosystem, because the researchers calculated that the decline in moth visitations could result in a 28 per cent drop in how much fruit the plants produce.**

**"This is just another reason that we should switch to energy sources that do not involve combustion," says team member Joel Thornton, also at the University of Washington. Chen Ly**

## *Really* brief



SCHMIDT OCEAN INSTITUTE

### Giant underwater mountains found

**Four new underwater mountains (two pictured above) have been discovered off the west coast of South and Central America by research vessel Falkor (too). The tallest is almost 3 kilometres high. Seamounts are hotspots of deep-sea biodiversity, offering a home for coral reefs and many animals.**

### Spirals turn contact lenses multifocal

**Inscribing a spiral in the centre of a contact lens helps it produce clearer images of objects at all distances than standard multifocals do, even in dim light. The spiral seems to twist the light rays and create optical vortices that somehow interact with each other (*Optica*, doi.org/mf8t).**

### Hottest January ever recorded

**This January was the hottest on record globally, at 1.7°C above the pre-industrial average for the month, says the European Union's Copernicus Climate Change Service. This means there has been a 12-month period in which the average global surface temperature was more than 1.5°C above the 1850 to 1900 average.**

Events

NewScientist

Instant Expert

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**Rob Edgecock**
Professor, Accelerator Applications,
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**Sinead Farrington**
Professor of Experimental Particle Physics, University of Edinburgh

**Gavin Hesketh**
Professor, Physics,
University College London

**Chris Parkes**
Leader Large Hadron Collider Beauty Experiment, CERN

**Melissa Uchida**
Lecturer, High Energy Physics,
Cavendish Laboratory,
University of Cambridge

# Views


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**Graham Lawton** is inspired by Pitcairn's conservationists p22

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A polar bear picks a perilous spot for a snooze p24

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Menstrual labels might face resistance in the US p26

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*A Brief History of Love* asks why we fall for each other p28

**Culture columnist**
**Emily H. Wilson** on the Hugo awards controversy p30


Comment

# Let's talk about love

The science of relationships shows there aren't five love languages, despite claims on TikTok, say **Emily Impett**, **Haeyoung Gideon Park** and **Amy Muise**

LOVE languages have permeated popular culture. On TikTok, videos about them have billions of views. On dating shows such as *The Bachelor*, contestants reveal their love language to potential suitors to gauge their compatibility, and on dating apps such as Hinge and Bumble, people can display their love language on their profile for potential partners to see before they even go on a first date.

Although today love languages have become a cultural obsession, the original idea had modest origins. Gary Chapman first published *The Five Love Languages* in 1992, based on his experience as a Southern Baptist pastor counselling couples. He determined that there are five love languages: physical touch, words of affirmation, acts of service, quality time and gifts.

SIMONE ROTELLA

Chapman says we all have a primary love language and the key to lasting love is to learn to "speak" a partner's preferred language. These ideas clearly resonate with people: the book has sold more than 20 million copies and has been translated into 50 languages.

As psychologists who study close relationships, we were sceptical, so we published a review of the scientific studies on love languages, none of which convincingly supported Chapman's claims.

According to this framework, people have a primary or preferred language, but the online quiz Chapman developed to test this forces people to pit the five love languages against one another. For example, people need to decide whether "holding hands" or "receiving gifts" is more meaningful to them. In real life, when people don't actually need to make these trade-offs, they see all five ways of expressing and receiving love as important. What the science of love reveals is that if love were a language, we would all need to be multilingual.

Chapman also says that because people tend to express love the way they want to receive it, partners who have the same love language should be happy in their relationship. He also suggests that even partners who don't share the same love language can cultivate love by learning to express it in the way the other person finds most meaningful. Instead, our review of the research showed that people report higher satisfaction when their partner expresses love in any of the languages.

As for the claim that there are five love languages, research on relationships suggests there are other meaningful ways that people express and receive love, such as supporting a partner's autonomy or personal goals outside the relationship.

Chapman's oversight in not identifying these behaviours in the original five love languages probably stems from his reliance on a limited sample of couples who were all married, religious, heterosexual and shared traditional values.

What the science of relationships suggests is that love isn't a language we need to learn to speak, but is more akin to keeping a nutritionally balanced diet. Whereas Chapman's language metaphor implies that people can only feel love when their partner speaks their love language, our diet metaphor suggests that people need multiple nutrients to maintain happy relationships, and keeps all types of expressions of love on the menu.

Much like a partner might mention they are craving spaghetti bolognese for dinner, they can also share when they need a supportive ear, would like to plan a date night or need help with a household task. When looking for a partner, it is less important to find someone who knows how you scored on the love languages quiz and more important that both partners understand that lasting love takes work and effort.

Emily Impett and Haeyoung Gideon Park are at the University of Toronto. Amy Muise is at York University, Canada

No planet B

# In deep water

I travelled for days to the remote Pitcairn Islands, a shining example of ocean conservation. But so much more needs to be done to protect our seas, says **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

## Graham's week

**What I'm reading**
Deep Sea and Foreign Going: Inside shipping, the invisible industry that brings you 90% of everything *by Rose George*.

**What I'm watching**
*I missed a lot of TV on my travels so am furiously catching up.*

**What I'm working on**
*Resetting my bamboozled body clock.*

This column appears monthly. Up next week: Annalee Newitz

LIKE many British people, I have always been vaguely aware of the existence of a place called the Pitcairn Islands. I would have struggled to point to it on a map, let alone name which ocean it is in. But I have just been there. It is a British overseas territory in the South Pacific, a four-day sail from Tahiti and over 500 kilometres from the nearest inhabited island – and the epic journey was worth it.

Pitcairn's history is captivating. It was the final destination in 1790 of some of the Bounty mutineers and most of its inhabitants today are direct descendants of those men and Tahitian women. But I didn't go there for that sort of bounty. The islands are at the centre of one of the world's biggest, most successful marine protected areas (MPAs), an oceanic nature reserve three-and-a-half times the size of the UK and a glittering example of how to do ocean conservation well (in a clamshell, stop outsiders from taking all the fish).

There are four islands, though only the one known as Pitcairn is inhabited. The territory's exclusive economic zone (EEZ), which runs for 200 nautical miles in every direction (except where it butts up against French Polynesia), covers some 842,000 square kilometres. Most is highly protected. I don't often praise the UK government on green issues, but hats off to it for recognising the biodiversity value of this remote tract of ocean and protecting it with vigour. Hats off to the islanders, too, for embracing the project.

Thanks to places like Pitcairn, the UK is one of only two countries to have exceeded the global target of protecting 30 per cent of its ocean surface. For pub quiz enthusiasts, the other is Palau, which has protected 78 per cent of its waters. The 30 per cent target is scientifically validated as the bare minimum required to halt the catastrophic loss of biodiversity. At the latest talks on biological diversity, in Canada in 2022, the world signed it off as a commitment to be met by the end of the decade, both on land and sea. This "30 by 30" goal has been described as biodiversity's equivalent to the ambition to limit global warming to 1.5°C.

Protecting 30 per cent of the ocean is even more difficult than protecting a similar area on land. I travelled to Pitcairn as a guest of the Royal Navy. We sailed on the

**"I don't often praise the UK government on green issues, but hats off to it for protecting this remote bit of ocean"**

HMS Tamar, one of its greenest ships. At some point, we crossed from the EEZ of French Polynesia into that of Pitcairn, but there is no sign to indicate it. Fish, turtles and whales can freely leave and re-enter an MPA, which makes protecting marine species more difficult than terrestrial ones. Even so, Pitcairn's MPA is among the most effective in the world.

The UK also has vast areas of highly protected waters around two other overseas territories: South Georgia and the South Sandwich Islands; and Saint Helena, Ascension and Tristan da Cunha. Another, Bermuda, is establishing an MPA. Credit must also go to the UK for designating the 638,097 $km^2$ EEZ of the British Indian Ocean Territory (aka the Chagos Archipelago) an MPA. That said, the UN General Assembly and the International Tribunal for the Law of the Sea have recognised the territory as belonging to Mauritius.

It is easy to be cynical about the UK's success, as protecting remote overseas territories is easier than doing it at home. Large areas of the UK's domestic EEZ are designated as MPAs, but aren't strongly protected. One scientist I spoke to described them as "a fraud".

However, not all former colonial powers with vast oceanic territories have done the same as the UK. France has roughly twice the overseas EEZs of the UK, but only tiny scraps are fully protected. The uninhabited French Southern and Antarctic Territories alone cover nearly 2 million $km^2$; only 6.3 per cent is fully protected. French Polynesia also has a huge EEZ covering 4,766,691 $km^2$, none of which is protected.

Admittedly, populated island nations rely on their seas for food and economic development. The Pitcairn islanders are allowed to fish for their own needs and to sell to passing cruise ships. If Bermuda establishes its MPA, 80 per cent of the EEZ will be open to fishing. But still, most island nations and overseas territories could and must do better.

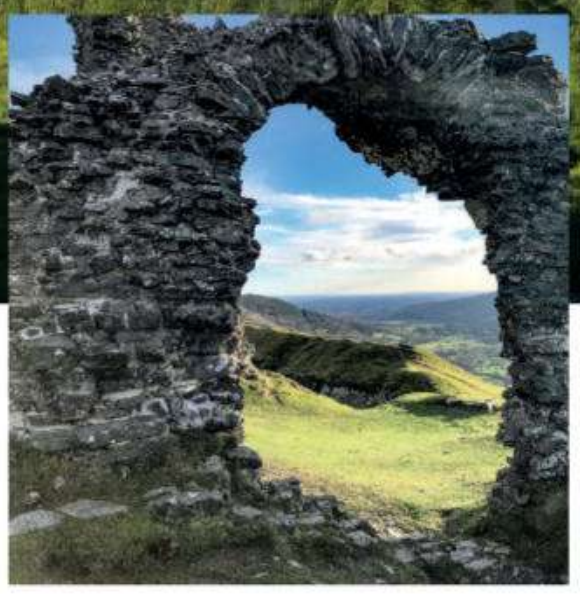
There is also the small matter that protecting 30 per cent of the oceans will require vast areas of international waters to be included; EEZs only cover about a third of the ocean and there is no way they can all be turned into MPAs. Facilitating international MPAs is a key feature of last year's High Seas Treaty, but so far only Chile and Palau have ratified it.

I left Pitcairn with huge respect for the islanders' commitment to preserving their precious ocean ecosystem, but also frustration that so many similar opportunities aren't being taken. The end of the decade is less than seven years away; 30 by 30 already looks dead in the water. ▮

Discovery Tours

NewScientist

# Explore the science behind these amazing landscapes



## Retracing Charles Darwin's travels across North Wales

**13 May 2024 | 6 days**

Uncover the best of Wales as you explore the dramatic Welsh landscapes of Eryri (Snowdonia) National Park and examine the regions geology and how it has been transformed by volcanic and glacial activity over the years. Discover the story of Charles Darwin's 1831 and 1842 tours of Wales, and retrace his travels on this small group journey to Shrewsbury and Snowdonia.

## The Rockies and the Badlands: Geology and dinosaurs in Canada

**17 June 2024 | 7 days**

Explore the majestic Rocky Mountains west of Calgary and the otherworldly Badlands to the east, witness the stunning scenery and geology of southern Alberta. This tour includes two visits to UNESCO World Heritage sites, where you will see first-hand the rugged peaks and glacial features of the Banff portion of Canadian Rocky Mountain Parks and the bone-riddled badlands of Dinosaur Provincial Park.

## Dinosaur hunting in the Gobi desert: Mongolia

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NIMA SARIKHANI/WILDLIFE PHOTOGRAPHER OF THE YEAR

# Time for a nap

**Photographer Nima Sarikhani**
**Natural History Museum, London**

AS MIDNIGHT approaches in Svalbard, a young polar bear climbs onto an iceberg and carves himself a makeshift bed before falling asleep. This serene moment, capturing the essence of Earth's fragility, was taken by Nima Sarikhani, who won this year's Wildlife Photographer of the Year People's Choice Award, which is decided by public vote.

Sarikhani, from the UK, spent three days searching Norway's Svalbard archipelago in the hope of catching a glimpse of these iconic Arctic animals. He was finally rewarded with the sight of both an older and younger male after his expedition vessel decided to change course. Sarikhani seized the chance to snap the younger bear dozing off on the iceberg – a scene that not only evokes the bond between an animal and its habitat, but also the need to act on global challenges like climate change and habitat loss.

These days, the sight of a lone polar bear on melting ice is a familiar symbol of the impact of climate change. But that is for a good reason: global warming is having a particularly rapid effect in the Arctic, which is heating up at a rate triple that of the average around the world. Among those hardest hit are these bears, which are increasingly threatened by the reduction in sea ice cover that they rely on to hunt and raise young.

Though his shot is intended to stir emotion in those who see it, Sarikhani is optimistic that it will ultimately inspire hope that, with the right actions, it isn't too late for polar bears. The image will be displayed in an exhibition at the Natural History Museum, London, along with the competition's four runners up, until 30 June.

**Gege Li**

## Editor's pick

### On the evolution of the menopause

**27 January, p 30**

*From Guy Cox, Sydney, Australia*

**Historical life expectancies reflect infant and child mortalities much more than adult lifespan. In other words, a woman who had lived until menopause at 50 would probably live for 20 more years to the biblical three score and 10. So, while I am not denying the value of grandmothers (let's be clear that we benefited from them and now so do our children), in ancient societies with no contraception, a woman was likely to have children up until menopause and therefore had to live 20 years longer just to support her own offspring. So, the surprising post-menopausal lifespan could be more to do with this.**

*From Geoff Harding, Sydney, Australia*

"Mysterious you" presents a fascinating argument for the evolution of menopause in women. However, the question remains why evolution has permitted men to continue the possibility of procreation into older age. Perhaps it has done its best to hamper this with a shorter lifespan.

### Menstrual labels might face resistance in the US

**27 January, p 19**

*From Bill Fishman, Los Angeles, California, US*

Jen Gunter's comment on the reluctance to market menstrual products using that word is sensible, helpful and represents the world I want to live in. But I am in the US, where half the people believe that anything that appeals to liberals is wrong, unacceptable, literally taking dictation from the devil and to be fought against by any means. What are merchants to do, knowing that using the right word, "menstrual", will result in demonstrations, boycotts and interfering laws? Maybe the UK can give it a try and let us know how it goes.

### Long-term survival? No brain required

**Letters, 3 February**

*From Bruce Denness, Niton, Isle of Wight, UK*

In believing that humans will still exist in billions of years, several readers attribute differing degrees of faith in our mental agility to see us through the death of the sun. However, big-brained *Homo sapiens* has been around for less than a million years, whereas jellyfish have chalked up over 500 million with no brain at all. So, as in some corners of society, airheads may trump brains after all.

*From Richard Swifte, Darmstadt, Germany*

Assuming humans survive into the far future and continue to develop technologically, I reckon we will be able to construct and maintain a system of shields situated at a stable point between Earth and the sun that would reduce solar radiation reaching us and enable an ideal temperature, buying us at least some time before our star goes red giant.

### Let the AIs help us in search for aliens

**3 February, p 9**

*From David Marjot, Weybridge, Surrey, UK*

In NASA's search for the biosignature of life on other worlds, could artificial intelligence help? When considering life's chemical origins, two relatively simple structures that appear to have self-replicating properties are prion proteins and types of RNA. For life to get going, these would need suitable substrates on which to develop. We might be guided to even simpler self-replicators and substrates by AI.

### Free buses may not reduce motor traffic on the roads

**Letters, 30 December 2023**

*From Eric Kvaalen, Les Essarts-le-Roi, France*

Merlin Reader advises free public transport as one way to have fewer cars on the roads. I advocated that for years, but then learned that it has been implemented in some French towns, and the result wasn't less car use. The people who used the free transport were those who would normally walk or go by bike (which means they got less exercise!). I think we need more of a carbon tax.

### Echoing your call to end neglect of women's health

**Leader, 6 January**

*From Jane Still, Wangaratta, Victoria, Australia*

As a menopausal woman of 54 and a mother, I was gratified to read your editorial on the unequal treatment of women's health issues. Last year, I – and the many hundreds of thousands of women who have had to struggle to get an appropriate treatment for this "natural" phase of our lives – was met with the news that one of the most efficient and convenient options, dermal patches providing oestrogen, was going to be next to impossible to obtain for the foreseeable future.

So, while the market sorts itself out, we women know that if this were an erectile dysfunction drug or got rid of wrinkles, there would be no end of money thrown at it. If that isn't enough to spark menopausal rage, I don't know what is.

### Will moon gravity affect quantum consciousness?

**20 January, p 32**

*From Adrian Bowyer, Foxham, Wiltshire, UK*

Roger Penrose and Stuart Hameroff propose that consciousness arises when a gravitational field causes quantum wave functions in microtubules in our neurons to collapse, so-called orchestrated objective reduction. The gravity on the moon is a sixth of that on Earth. So, if the idea were correct, we would have expected to see consciousness changes in lunar astronauts. As far as I am aware, none was observed. Perhaps the Artemis programme could investigate this.

### There are ways to solve hydrogen fuel problems

**3 February, p 32**

*From Tim Hallpike, Christchurch, Dorset, UK*

The shortcomings of using hydrogen as a fuel that were summarised in your article, relating to efficient and stable storage and transport, can be addressed by using chemicals that combine with the hydrogen, called liquid organic hydrogen carriers. These were successfully trialled during the recent European Union-funded HySTOC project. In addition, the technology relating to turquoise hydrogen, in which the gas is produced from methane without releasing carbon dioxide, has now reached what is known as technology readiness level 9 at the Olive Creek plant in Nebraska. That level indicates the most mature technologies.

## For the record

**Joachim Moortgat at the Ohio State University contributed to work to identify natural hydrogen deposits via soil circles (3 February, p 32).**

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# The problem with love

Can we ever know what love is, given the clash between our evolution and a fast-changing culture? **Elle Hunt** welcomes a clear account of the issues

Book

**A Brief History of Love**

**Liat Yakir**

**Watkins Publishing**

FILIPPOBACCI/GETTY IMAGES

**Technology has transformed dating – for better or worse**

IT IS just over 30 years since the Eurodance singer Haddaway posed the question "What is love?" and we still aren't much closer to consensus. Despite the enduring, bottomless interest in love, our knowledge about what it actually is that brings and keeps people together is limited.

What's more, the parameters are changing all the time. In many so-called WEIRD (Western, educated, industrialised, rich and democratic) societies, marriage and birth rates are in decline, with women in particular opting to stay single. Meanwhile, technology has transformed the search for love – not necessarily for the better.

"All this has happened within a few generations," marvels Liat Yakir, a biologist and lecturer specialising in genetics. In *A Brief History of Love: What attracts us, how we fall in love and why biology screws it all up*, she aims to bring science and social and cultural factors to bear on the question: what's love got to do with it?

Yakir sets aside her personal experience (as a two-time divorcee and single parent of two) to "try to understand what love is biologically, chemically and genetically". Drawing on a wide range of studies, most from evolutionary psychology, Yakir sets out how genes and hormones have influenced not only our individual experiences of love and attraction, but steered the course of humanity.

One minor example is the evolution of blue eyes, a genetic mutation that spread from one common ancestor and now makes up 8 per cent of the global population: "dizzying" evidence, says Yakir, of the impact of sexual selection. "Most of us are attracted to those who seem special in some way." (A recent study, however, offers another explanation: blue eyes can aid vision in low light.)

Today, dating apps take that desire for novelty to the extreme, as they present an overwhelming array of potential partners. The brain, says Yakir, "is not built for such a load of stimuli", which ends up complicating the search for a partner and long-term love.

**"Any struggles we might have with sex, love and relationships are partly a reflection of our 'confused age'"**

It goes to show that, though the contexts and circumstances in which we seek relationships might have changed beyond recognition, many of the evolutionary drivers and neural pathways remain consistent and seem crude: for example, the desire for the feel-good hormone oxytocin, and the urge to pass on genetic material.

Yakir is an expert consultant for the Israeli version of the reality show *Married At First Sight* and this is reflected in her reader-friendly tone and engaging selection of material. Naturally, *A Brief History of Love* is full of interesting scientific morsels on the mating game.

Some may be disheartening to readers seeking love. Take the mathematical finding Yakir cites that people in the UK have a 1 in 562 chance of falling in love on any given day. Likewise, Yakir's point that, even among the estimated 5 per cent of species that mate with only one partner at a time, most "cheat at every opportunity". Only a dozen or so creatures are "genetically monogamous", pairing for life.

Humans, meanwhile, struggle to come down in favour of stability versus novelty, flagging us as neither naturally polygamous or monogamous but "a tragically confused species", to quote the renowned neuroscientist and biologist Robert Sapolsky.

For singletons still hopeful of finding lasting love with one another, Yakir acknowledges that her findings may register as "more and more depressing". But there is also perhaps some relief in gaining greater understanding of the biological imperatives underpinning our impulses and behaviours, and why they might be poorly suited to modern times.

Yakir argues that any struggles we might have with sex, love and relationships are at least partly a reflection of our "confused age", and the evolved instincts and strategies that are no longer so essential to our species' survival. Modern dating advice can be over-complicated and even over-intellectualised, especially online. By contrast, Yakir's chapter of science-backed tips to find and keep "a long-lasting love" may register as a refreshing injection of clarity and common sense.

Sure, single women will need to be organised to schedule first dates around ovulation, as Yakir (perhaps naively) suggests it is a "good idea" to capitalise on the flattering effects of elevated oestrogen. And couples of long standing may struggle with the advice to swap five compliments daily and stare deeply into each other's eyes "for at least 30 seconds", ideally while naked.

But when the pursuit of love is often represented as a cross between a "battle of the sexes" and a game of four-dimensional chess, it can be helpful to be reminded, as Bloodhound Gang sang 25 years ago, that we "ain't nothing but mammals" – and love is, at least on some level, what we see done "on the Discovery Channel". ▮

Elle Hunt is a writer based in Norfolk, UK

# Keeping it real

Two new documentaries take very different approaches when it comes to portraying the wonders of nature, finds **Josh Bell**

TV

**Arctic Ascent with Alex Honnold**
National Geographic
Disney+

**A Real Bug's Life**
National Geographic
Disney+

ALEX HONNOLD isn't the most likely celebrity. The world-class rock climber first entered the mainstream via the Oscar-winning 2018 documentary *Free Solo*, which chronicled his successful effort at a free solo climb (alone, without any support equipment) of the El Capitan summit in California's Yosemite National Park.

Since then, he has become an unofficial pop-culture ambassador of rock climbing, appearing in other documentaries and working with National Geographic on nature specials. Honnold seems to have embraced his position, retaining his unique blend of humility and hubris. He is quick to point out his insignificance compared with the plight of Earth, and he has used his growing fame and fortune to focus attention and resources on climate change.

Honnold retains a fearlessness as a climber that borders on arrogance, and both are on display in an engrossing three-parter. In *Arctic Ascent with Alex Honnold* (as in his previous Nat Geo special, *Explorer: The last tepui*), the climber combines his challenge with a scientific endeavour. In this case, it is the study of melting Greenland ice caps that could lead to the rise of sea levels. He may be the celebrity, but *Arctic Ascent* affords ample time to other members of his team, such as glaciologist Heïdi Sevestre. Along with two other climbers, a safety officer and a local guide from Greenland, Honnold and Sevestre set out across the Renland ice cap to gather data from areas with no documented human exploration.

As important as Sevestre's scientific efforts are, Honnold and the producers understand that the real appeal for most viewers is seeing the climber accomplish a seemingly impossible feat, and he does just that by being the first to ascend the 1219-metre rock formation known as Ingmikortilaq.

*Arctic Ascent* is structured like a conventional adventure reality show and it doesn't achieve the same level of suspense or personal stakes as *Free Solo*. Even so, there are plenty of awe-inspiring moments as the cameras pull back to show Honnold and his fellow climbers barely clinging to massive, sheer rock walls.

The series may be carefully packaged, but such moments still convey the genuine danger and unpredictability of the situation. It is almost the exact opposite of the other Nat Geo series premiering on Disney+ recently, the cutesy and heavily stylised *A Real Bug's Life*.

Piggybacking on the enduring popularity of the 1998 Pixar movie *A Bug's Life*, the series is meant to be a family-friendly introduction to the insect world. But it is such a constructed product that it might as well be animation, and even young viewers are likely to spot that it doesn't seem real. A disclaimer that flies by at the end of each episode notes that "some sequences have been graphically enhanced or were filmed under controlled conditions", but that is insufficient to describe the sound stage that substitutes for New York City in the first episode or the digital composite of a suburban backyard in a later instalment.

When the show travels to the actual Costa Rican jungle, it feels more authentic, although the corny narration from rapper and actor Awkwafina and the contrived narratives for the bug protagonists still highlight the manipulation.

Of course, it is good to leverage Pixar's appeal to help preserve the natural world, but *A Real Bug's Life* never seems anything but contrived. When Honnold raises awareness about the environment by climbing all over it, his concern and passion shine through with urgent honesty. ▮

Josh Bell is a writer and critic based in Las Vegas, Nevada

Rock climber Alex Honnold inside a moulin – or shaft – in Greenland

NATIONAL GEOGRAPHIC/MIKEY SCHAEFER

## New Scientist *recommends*

**Tom Leslie**
**Subeditor**
**London**

I have been wandering London in search of hidden gems and recently enjoyed the **Chelsea Physic Garden** (pictured). Established by a society of apothecaries in the 17th century to

grow medicinal and otherwise useful plants, its walled garden brims with botanical curiosities, including familiar faces such as the opium poppy and willow tree.

More obscure varieties also merit a mention, if only for their names. My favourites are the hardy succulent known as old father live forever, and an unassuming but highly toxic shrub called the poison devil's pepper.

At home and on my commute, I trade botany for disease ecology in the form of **This Podcast Will Kill You**. Here, epidemiologists Erin Allmann Updyke and Erin Welsh neatly balance eye-opening first-hand accounts and their own fastidious research with a healthy dose of fun and humour. Each episode also includes a themed cocktail, but I wouldn't blame you for giving the cholera-inspired "rice-water stool" a miss.

JOHN BRACEGIRDLE/ALAMY

The sci-fi column

# A silver lining

The Hugo awards are the Oscars for sci-fi and fantasy fans, so any oddities in the voting data for 2023's ceremony in China are bound to be upsetting. But whatever the reality, **Emily H. Wilson** finds an unexpected upside

Emily H. Wilson is a former editor of *New Scientist*. *Gilgamesh*, the second novel in her *Sumerians* trilogy, is out later this year. Find her website at emilyhwilson.com and follow her on X at @emilyhwilson and on Instagram @emilyhwilson1

XINHUA/SHUTTERSTOCK

**The 2023 Hugo awards in Chengdu, China, are caught up in controversy**

IT IS a truth universally acknowledged that all awards are total bunk except for the ones you personally have lifted into the air in triumph. That rule doesn't hold, however, if your prize is in some way sullied later on. This, sadly, is the situation for the winners of the 2023 Hugo awards.

The Hugos are the world's most prestigious science fiction and fantasy (SFF) prizes, launched in 1953 and awarded every year since 1955. Writers have long dreamed of winning one, and readers trust them as a barometer of excellence.

Last year's Hugos ceremony took place in Chengdu, China, in October, passing with little comment. But the voting data has been released and it throws up oddities. Certain nominees were marked "ineligible", with no explanation offered. It does seem odd, in retrospect, that a hugely successful SFF book like *Babel* by R. F. Kuang failed to progress. Were all those marked ineligible somehow unpalatable to the Chinese state?

There may be an innocent explanation. I am a big believer in screw-up over conspiracy. But it is unclear whether we will find out because the Hugos are awarded through a complex, decentralised system that would take a column to explain.

If consulted, I would have advised against holding a literary awards process in a country where censorship and its evil twin,

**"How did Iain M. Banks never win a Hugo for his superb and vastly influential *Culture* series?"**

self-censorship, are pillars of the state. But the Hugos-in-China debacle did spur me on to look up all the winners since 1955.

The first thing to note is that you might imagine only men were eligible to enter in the early years. Gender issues aside, there look to have been serious omissions. How did Iain M. Banks never win a Hugo for his superb and vastly influential *Culture* series? (Actually, there seems to be a complicated explanation for that, involving UK vs US publishing.)

But the list of winners isn't a bad guide to the best SFF over 70-odd years, especially if you look beyond "Best Novel" to other categories. The great Octavia E. Butler, for example, never received that gong, but did win Best Novelette and Best Short Story.

It has reminded me of so many wonderful books, from Vernor Vinge's brilliant *A Fire Upon the Deep* to Kim Stanley Robinson's majestic *Red*, *Green* and *Blue Mars* series. And over the past decade, the awards have celebrated more amazing talents, including women such as Ann Leckie.

She won Best Novel in 2014 for *Ancillary Justice*, a book I force on everyone I know. Massive spaceships, terrifying alien ambassadors, wonderful writing: what's not to love?

We have also had Cixin Liu's stunning *Three-Body Problem*, first of a trilogy. That's a series I force on anyone who says they are into physics because it is a long "what if" about how we could accelerate physics research if our fate depended on it (which, er, it may, with climate change).

And on the fantasy front, N. K. Jemisin's dazzling *Broken Earth* trilogy is a triumph of world-building. Each book won a Best Novel Hugo!

This isn't the first Hugos controversy. From 2013 to 2017, mysterious groups tried to skew the voting in a fight-back against an alleged "woke" agenda. The Hugos survived, so let's hope they continue as a beacon of good SFF. Reassuringly, the organisers of the 2024 event in Glasgow, UK, say they are committed to full transparency if anyone is marked "ineligible". ▮

## Emily also recommends...

Book

**Machine Vendetta**

**Alastair Reynolds**

Gollancz

*Away from the Hugos, this is the third of Alastair Reynolds's detectives-in-space series, and I think I need to go back to the beginning of the trilogy to get the fullest enjoyment.*

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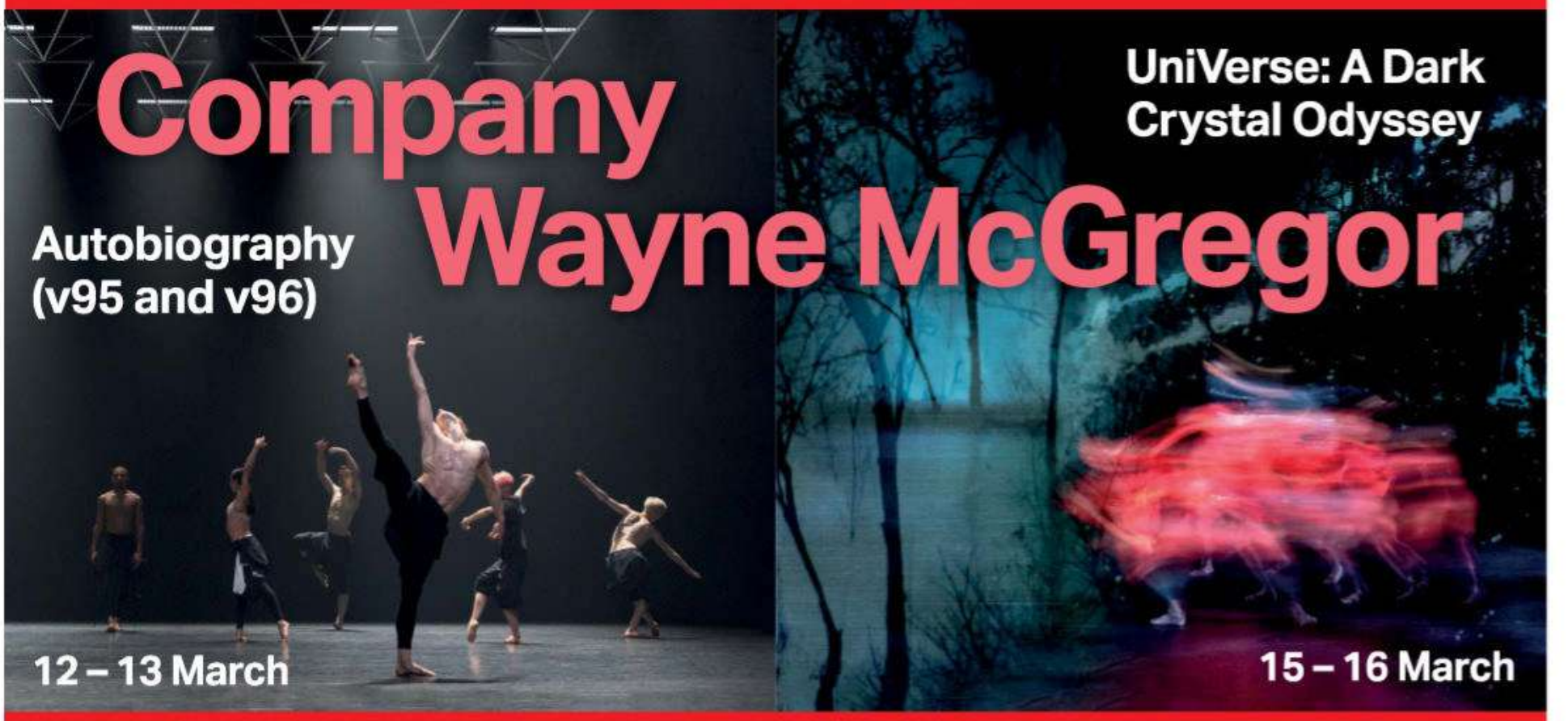


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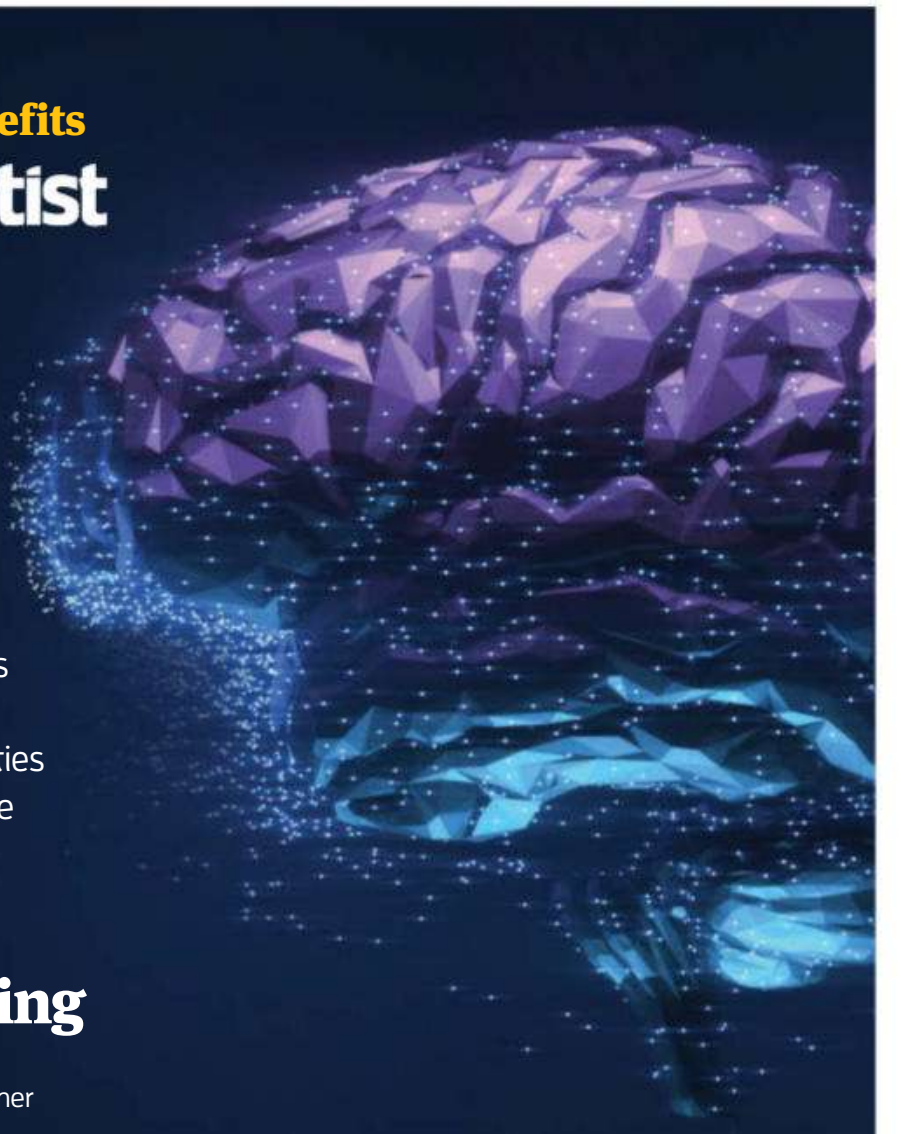

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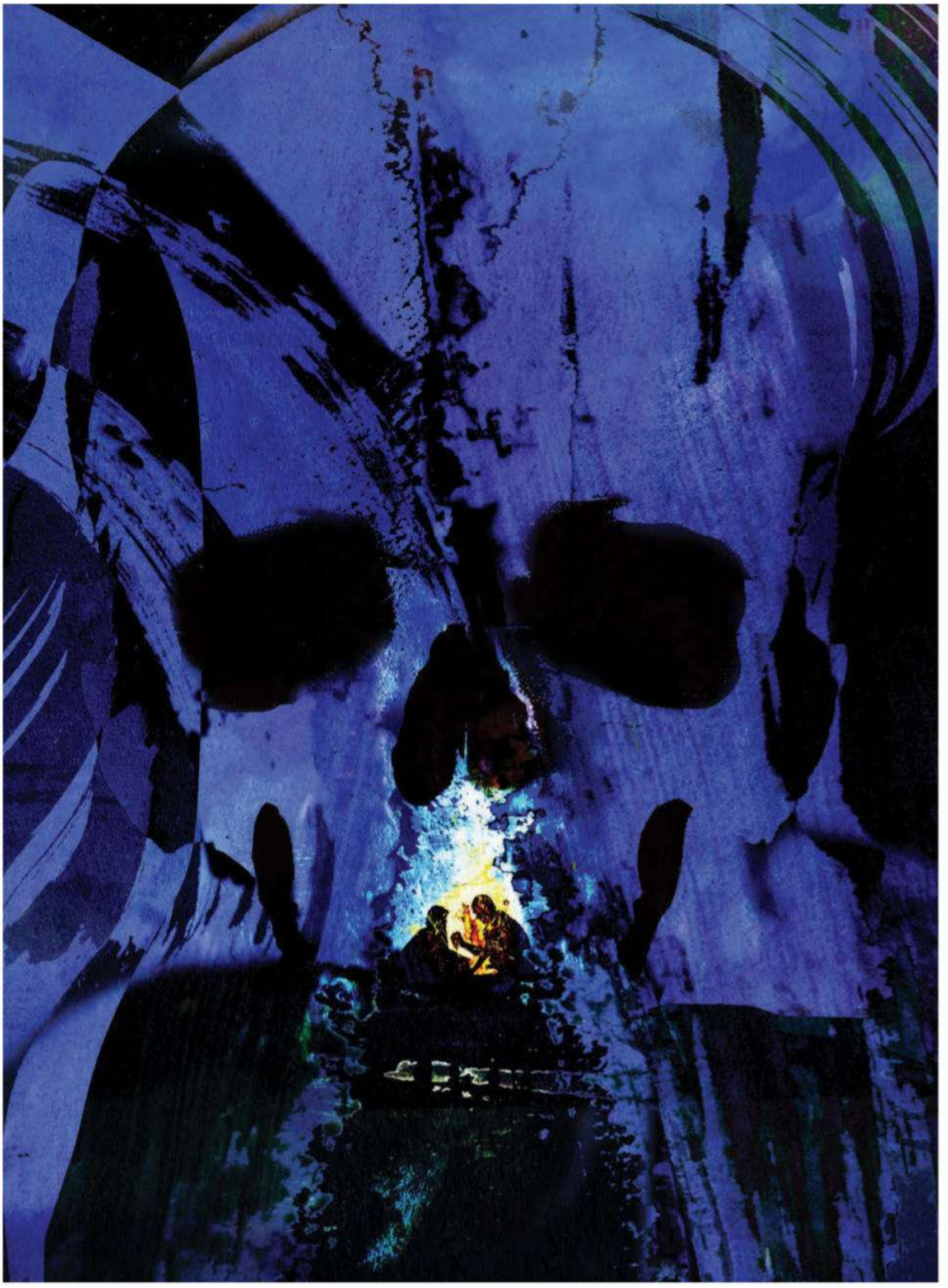

SIMON PEMBERTON

# Fine old cannibals

Humans have a very long history of eating each other, and they may have done so for all the right reasons, finds **Michael Marshall**

IN GOUGH'S cave in Cheddar Gorge, south-west England, archaeologists have found the remains of at least six individuals. Many of the bones were intentionally broken and the fragments are covered in cut marks, the result of people using stone tools to separate them and remove the flesh. What's more, 42 per cent of the bone fragments bear human teeth marks. There is little doubt: the people who lived in this cave 14,700 years ago practised cannibalism.

Today, cannibalism is a taboo subject in many societies. We see it as aberrant, as is clear in films such as *The Texas Chain Saw Massacre*. We associate it with zombies, psychopaths and serial killers like the fictional Hannibal Lecter. Positive stories of cannibals are few and far between. But perhaps it is time for a rethink because, despite our preconceptions, evidence is accumulating that cannibalism was a common human behaviour.

Our ancestors have been eating each other for a million years or more. In fact, it seems that, down the ages, around a fifth of societies have practised cannibalism. While some of this people-eating may have been done simply to survive, in many cases, the reasons look more complex. In places like Gough's cave, for example, consuming the bodies of the dead seems to have been part of a funerary ritual. Far from a monstrous affront to nature, cannibalism may be a way of showing respect and love for the dead, say some archaeologists.

Tales of cannibals can be found throughout human history. In Homer's *Odyssey*, written some time before 600 BC, the Greek hero Odysseus loses many of his men and ships to a tribe of cannibalistic giants called the Laestrygonians. Similar narratives, of noble heroes falling foul of nefarious cannibals, have recurred ever since.

Things got darker during the colonial era when oppressors used the racist stereotype of the "cannibal native" to justify conquest and exploitation. Concocted stories about missionaries being boiled in pots reinforced the idea that Indigenous populations were engaged in barbaric behaviours and needed to be "civilised" – by force, if necessary. That, in turn, led to a backlash, culminating in 1979 with the publication of a book called *The Man-Eating Myth* in which anthropologist William Arens argued that there was no good evidence of cannibalism in any society, ever.

Nevertheless, many anthropologists felt that, in his zeal, Arens had dismissed some evidence. And over the next two decades, they developed more rigorous methods to detect it. The key challenge was to distinguish cannibalism from other activities that look superficially similar, such as removing the flesh from dead bodies but not subsequently eating it. Taking this approach, in 1986, Paola Villa at the University of Colorado Boulder and her team found good evidence of cannibalism in Fontbrégoua cave in France. People living there in the Neolithic period, between 4700 and 3100 years ago, had butchered human bodies and processed them in similar ways to prey animals.

A few years later, Tim White at the University of California, Berkeley, concluded that Ancestral Puebloans in south-west Colorado also ate their dead. Around AD 1100, at least 29 people, both adults and children, were butchered and cooked there, with their bones broken open for marrow. Meanwhile, husband-and-wife team Christy Turner at Arizona State University and Jacqueline Turner documented more instances of cannibalism at 38 sites in the US Southwest, dating to between AD 900 and 1700.

## Plenty of leftovers

It is now clear that Arens went too far when he argued human cannibalism has never existed, says Silvia Bello at the Natural History Museum in London. "We do have visual evidence now," says Palmira Saladié at the Catalan Institute of Human Paleoecology and Social Evolution in Tarragona, Spain. "The methods and techniques used are precise and hardly leave room for doubt."

The next question is whether cannibalism was rare or commonplace. To answer that, we need systematic investigations, across multiple places and times. For now, the most compelling evidence comes from Europe, partly because the prehistory of that continent has been so thoroughly excavated.

Europe has a long history of human habitation, as multiple waves of hominins migrated there from their African homeland. Our species, *Homo sapiens*, was the most recent arrival, becoming established around 45,000 years ago. Before that, Neanderthals dominated Europe for hundreds of thousands of years, and before them there were other species of the genus *Homo* dating back over 1 million years. These early Europeans clearly practised cannibalism – but how often?

Among the Neanderthals, it was pretty common. "About 20 per cent of the sites show evidence," says Bello. The rates are similar for *Homo sapiens*, she adds – between 20 and 25 per cent of sites – but there is much more variability between cultures and periods. In the Magdalenian era, between about 23,500 and 13,500 years ago, it was surprisingly frequent, as Nohemi Sala at the National Research Centre on Human Evolution in ›

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JAN SKWARA

**The Aghori of India sometimes practise funerary cannibalism**

Burgos, Spain, discovered in a study of cut marks on human bones from Germany. However, in the subsequent Mesolithic period, cannibalism was rare. Then came the Neolithic – the period in which Europeans began farming – when eating other people came back into fashion.

The evidence from Europe also suggests that cannibalism goes back a long way, perhaps to one of the continent's earliest human settlers, *Homo antecessor*. They lived in caves in the Atapuerca mountains of northern Spain between 1.2 million and 0.8 million years ago. At one site, Gran Dolina, archaeologists found the remains of at least six people that had been cut up with stone tools, and some bones snapped by being bent like twigs. "Atapuerca at 1 million [years ago] is quite convincingly a case of cannibalism," says Bello.

It is possible cannibalism is even older than that. In a study published in June 2023, researchers led by Briana Pobiner at the Smithsonian Institution in Washington DC described a single hominin leg bone from Koobi Fora in Kenya. It was about 1.45 million years old and sported multiple cut marks. If it had been cannibalised, this would be the oldest example yet found. But many anthropologists remain sceptical. Saladié says no conclusions can be drawn from a single bone because it can't be studied in context. Bello points out that multiple hominin species lived alongside each other in Africa at the time, and we don't know who made the cut marks. "If it was a different species, then it's not cannibalism," she points out. Indeed, Pobiner's team didn't claim there had been cannibalism: it was only raised as one of several possibilities.

On the other hand, maybe we shouldn't be surprised if our hominin ancestors sometimes ate members of their species, because plenty of our primate relatives do it. Some monkeys turn cannibal at times. Even our two closest living relatives, chimpanzees and bonobos, sometimes eat young of their own kind.

## Food for thought

Regardless of how early in our evolutionary history our ancestors started eating each other, it is clear that, at least in the past few hundred thousand years, they did it quite often. Why?

Perhaps the simplest explanation is for food. People in dire straits sometimes resort to cannibalism to survive. This famously happened after Uruguayan Air Force Flight 571 crashed in the Andes in 1972. The recent film *Society of the Snow* tells how the survivors found themselves stranded high in a remote mountainous region with hardly any food. They agreed that anyone who died could be eaten by the survivors. Partly thanks to this decision, 16 people survived the ordeal.

Some instances of prehistoric cannibalism seem to follow a similar narrative. For example, there is evidence that Neanderthals living at Moula-Guercy in France around 100,000 years ago ate each other. Here, the bones of the cannibalised Neanderthals were mixed in with those of other animals, suggesting they were seen primarily as food. Furthermore, the Neanderthal population seems to have crashed in the area at the time, perhaps due to food shortages. "They do just seem to be genuinely eating the dead as part of survival cannibalism," says James Cole at the University of Brighton, UK. At Gran Dolina too, the *H. antecessor* bones were modified in similar ways to prey animal bones, and mixed in with them rather than given special treatment.

But it is one thing to eat people who have died, quite another to actively prey on humans. "The people you're hunting are not just going to be standing there passively, they're going to be defending themselves," says Cole. And the risk of killing one's enemies for food might not have been worth it, given that humans aren't especially nourishing. Cole has estimated that a typical Stone Age person would yield 144,000 calories and probably more like 126,000 if not

## Is it safe to eat people?

**You may have heard of kuru – a mysterious and fatal neurodegenerative disease found spreading among the Fore, an Indigenous group from Papua New Guinea, in the 1950s. Kuru was eventually linked to cannibalism.**

**The Fore consumed their dead rather than burying them and, when eating the brain, some people also ingested prions – strange malformed proteins that cause other proteins to become misshapen, resulting in fatal brain damage.**

**Given that we catch infectious diseases from other humans, it might seem logical that cannibalism carries the risk of disease. In reality, proper cooking and preparation will kill the majority of disease-causing agents. Of course, human flesh will spoil, in which case it may contain harmful microbes such as *Salmonella* and *Escherichia coli*, along with parasites and worms. But that makes eating humans no more dangerous than eating other animals.**

**The only heightened risk comes from the brain, because of prions. As well as causing kuru, they are also the agents behind Creutzfeldt–Jakob disease, the human equivalent of "mad cow disease" or bovine spongiform encephalopathy (BSE).**

**"It's definitely the brains you want to avoid," says James Cole at the University of Brighton, UK. "If you were just going for the flesh, the protein and the fat, those aren't infected."**

**This might help explain why, down the ages and across cultures, cannibalism has been surprisingly common (see main story).**

J. CLARK, HUMAN ORIGINS PROGRAM, NMNH, SMITHSONIAN INSTITUTION

JOSÉ-MANUEL BENITO ALVAREZ (CC BY-SA 4.0 DEED)

**Above: A jaw found in Gough's cave, UK, has marks where flesh was removed 14,700 years ago**

**Below: The zigzag markings on this ancient arm bone suggest it was used in a ritual of some kind**

LONGLEAT/CHEDDAR GORGE & CAVES

everything was eaten, such as organs like the spleen. The biggest energy hits came from fat layers (50,000 calories) and the skeletal muscle (32,000 calories). Larger animals yielded dramatically more calories: a mammoth would get you 3.6 million calories just from its muscles. "We're a relatively small animal compared to other game and therefore our calorie value is relatively small," says Cole.

It is unlikely that nutritional needs can explain all cases of cannibalism. Another possibility emerged when Saladié and her colleagues re-examined the cannibalised *H. antecessor* bones and realised that most of them were children. This is unlike most other cases of hominin cannibalism, but looks a lot like the way chimpanzees attack neighbouring groups. Aggressive chimp groups often target isolated youngsters, keeping the numbers down in rival groups at minimal risk to themselves. "It's about territory defence and maintaining borders," says Cole. *H. antecessor* may have done something similar.

The final type of motivation for cannibalism is very different. So far, the narratives have been about finding food or dealing with dangerous rivals. But cannibalism can also be a funerary ritual. Instead of burying or cremating the bodies of loved ones, as is now common in Western society, perhaps in some prehistoric societies they chose to eat them.

To find out whether that might be the case, Bello and her colleague William Marsh, also at the Natural History Museum in London, reviewed many instances of cannibalism in the Magdalenian period in Europe. The study, published in November 2023, supports the idea of funerary cannibalism in several ways. The human bones were often disposed of separately from those of animals consumed for food. Many had engravings on them: for instance, an arm bone from Gough's cave had a zigzag pattern cut into it that wouldn't happen during normal butchery, but would if it were ritualised in some way. Gough's cave and other sites also contain cups meticulously fashioned from human skulls, connoting ritual. Marsh and Bello were able to distinguish between cultures where funerary cannibalism was practised and those that favoured burial, because the people from these two groups had distinct genetic signatures.

"We must be careful when we judge," says Sala. Funerary cannibalism was done out of love and respect for the dead, as ethnographic accounts of it in recent human cultures attest. These include several prehistoric Scandinavian societies, as described in the book *Cremation, Corpses and Cannibalism*. Similarly, in her book *Consuming Grief*, Beth Conklin at Vanderbilt University in Tennessee describes the "compassionate cannibalism" practised by Brazil's Wari' society in the 20th century. "The idea is they eat it all, as much as possible," says Bello. "They burn what little is left, including the bones, which are then smashed, mixed with honey, and also that is eaten." For the Wari', leaving a loved one's body to decompose was "disrespectful". Some prehistoric societies in Fiji also ate loved ones during funerals, but probably only small portions.

Funerary cannibalism has been suppressed in recent decades, typically by Western colonial powers that viewed it as barbaric. One of the few communities that still practise it is the Aghori, a Hindu offshoot group in India. "It's not very common, but they actually collect bodies from the river and they just eat them," says Bello. In common with many prehistoric groups, the Aghori also use skulls as drinking vessels.

Behaviours like these may feel shocking and are still often presented as such. But, in light of the new evidence, some anthropologists now say it is time to ditch our negative views about cannibalism. "It's something that needs to be understood a bit better and not just associated to the horrible behaviour of a psychopath," says Bello. Cole goes further: "Cannibalism is not bad or unnatural. It's part of the natural world. We are an extension of that. And we've been doing it for at least a million years." ▮

"Funerary cannibalism was done out of love and respect for the dead"

Michael Marshall is a freelance writer based in Devon, UK

# The dream engineers

Manipulating the scenes that play out in our heads as we sleep can boost learning, break bad habits, banish nightmares and more, finds **Emma Young**

WHEN an ancient Egyptian sought an encounter with Bes, the god of fertility and childbirth, they would draw an image of the deity on their hand, wrap that hand and their neck with black cloth, and then settle down to sleep. This practice, described in a papyrus that dates to around 1350 BC, is the earliest documented example of the use of sensory stimulation to try to influence the content of a dream.

Three thousand years on, neuroscientists and psychologists are turning this ancient idea into something more scientific. Overturning long-held preconceptions about the disconnect between our brains and bodies during sleep, these "dream engineers" are using sounds, smells, touch and even bodily movements to influence the content of people's dreams. In doing so, they have achieved striking benefits, from improving sleep quality and mood to boosting learning and creativity.

Better yet, the dream engineers are now developing dream-induction devices that can be used by anyone in their own home. This raises the prospect that we could all soon be harnessing our sleeping hours to our advantage. However, the power of these techniques on a resting mind is leading some, not least the researchers themselves, to worry about the potential for misuse. "I have no doubt that dream engineering could open many minds, heal others and help us to understand one another more clearly," says Adam Haar Horowitz at Massachusetts Institute of Technology. "It could also become an advertising gimmick. We have to proceed with caring and watchful eyes."

Dream engineering isn't the same as lucid dreaming, where some people can become aware of their dream world and learn to direct the action. Psychologists have been interested in this method of hacking dreams for over a century. But lucid dreaming is tough to master. What's more, it entails a level of conscious control by the dreamer, whereas manipulation through dream engineering doesn't. "It involves dialogue with a self we cannot access while awake," says Haar Horowitz.

A desire to find a way to "talk" to this inner voice has inspired him and others to try to influence dreams without the dreamer's conscious awareness. Until recently, this seemed impossible because neuroscientists and psychologists thought that the brain was somehow disassociated from the rest of the body during sleep to prevent us from acting out our dreams. Now though, it is clear this isn't the case – and that's where dream engineers come in. As they put it in one study, the body is a "permeable barrier that can be used to interface with the virtual world of dreams".

Key to their ability to interface accurately is an improvement in knowledge about the patterns and functions of dreaming. This includes the recent realisation that dreams occur in all four stages of sleep, and that the style and typical content of them vary consistently between these stages. In the first, light stage, which represents the transition from wakefulness to sleep, we experience a state of mind called hypnagogia that Haar Horowitz describes as "trippy, loose, flexible and divergent". The "microdreams" that

DONGQIU

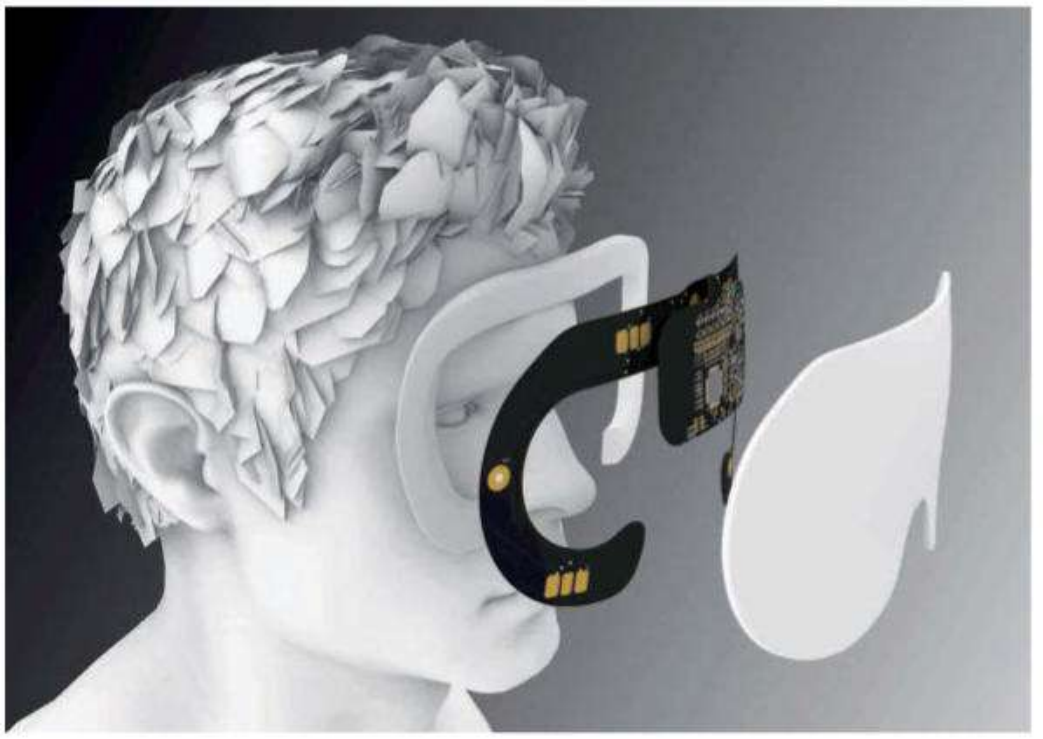
happen during this stage are very brief and often integrate real events, such as the sound of a window slamming, with recent experiences and associated memories – so the sleeper might dream of a book falling, say, or of someone knocking on the door. Stage two, which plays a role in assimilating facts and learning from experiences, and stage three, or slow-wave sleep, in which memories are reorganised, were once believed to be devoid of dreams. Now, studies of the sleeping brain have overturned this idea. These dreams are, however, more prosaic and shorter than those in stage four, or rapid eye movement (REM) sleep. In stage three, for example, you might dream that you are eating a biscuit, whereas in stage four, a biscuit might be a vital part of a complex action plot in which you are leading an army against alien invaders.

*"INFLUENCING DREAMS COULD OPEN MINDS, HEAL OTHERS AND HELP US UNDERSTAND ONE ANOTHER MORE CLEARLY"*

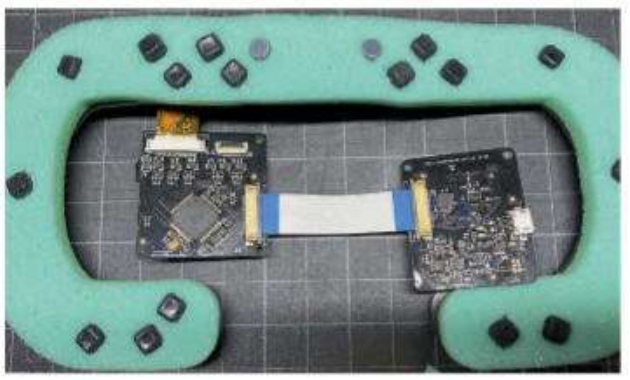
Early work on influencing dreams targeted experiences and interventions right before sleep. Conceptually, this wasn't far removed from the ancient Egyptian practice of focusing on Bes to conjure up a dream encounter with him. Still, some of the results were impressive. In one study, when students were asked to think about a personal problem for 15 minutes before sleep, about half reported having a dream that was related to their problem – and a majority of these believed that their dream contained a solution. A modern treatment for nightmares called imagery rehearsal therapy has a twist on this approach: people are advised to spend 5 to 10 minutes each night visualising a positive finale to a recurring nightmare before going to sleep – and studies show that this can subsequently rewrite the ending.

Other dream engineers are targeting dreams during specific stages of sleep. One approach uses scent, inspired by research showing that when pleasant odours are wafted over people in REM sleep, on waking they report having had happier dreams. In the same way, unpleasant odours can foster unpleasant dreams. This is thought to happen as a result of the positive or negative emotions that are provoked by certain odours. One study exposed a group of smokers who wanted to quit to the smell of rotten eggs plus the smell of cigarettes during stage-two sleep. They went on to smoke around 30 per cent fewer cigarettes on average the following week. A separate group exposed to the same odour combination while awake smoked just as many cigarettes as before.

A slightly different method involves teaching people's brains to pair a particular sensory stimulus, such as an odour, with a learning task while they are awake, and then uses that same sensory cue to activate memories of the task during stage-three sleep. This technique, called targeted memory reactivation (TMR), seems to work by tricking the hippocampus, a region of the brain that is important for memory. By evoking what looks like a spontaneous reactivation of a memory in the cortex, it influences what the hippocampus replays during sleep – and so enhances learning of that material. Studies have found that TMR can boost the learning of foreign vocabulary and improve performance at a visuospatial task. It can even help to tackle implicit social biases, as researchers at ›



GUILLERMO BERNAL, WALAA ALKHANAIZI B.S. M.I.T., 2019



**Fascia, which uses a face mask to detect your sleep stage, aims to improve sleep quality and enhance memory**

*"DREAM ENGINEERS ARE DEVELOPING DREAM-INDUCTION DEVICES THAT CAN BE USED BY ANYONE IN THEIR OWN HOME"*

Northwestern University in Illinois found when they paired unusual sounds with specific aspects of training on race or gender bias, and then replayed these sounds during slow-wave sleep.

TMR can also help to boost the effectiveness of imagery rehearsal therapy for treating nightmares. Sophie Schwartz at the University of Geneva in Switzerland and her colleagues recently studied 36 people who regularly experience nightmares. All spent time envisaging a better end to their bad dreams before sleep, but half were also exposed to the sound of a piano chord every 10 seconds while they did this. At night, each person wore a headband containing electrodes to monitor their brain activity. When it registered that they had entered REM sleep, the same piano chord was played every 10 seconds until the REM period had finished. After two weeks, both groups had fewer nightmares, but the piano chord group had significantly fewer than the other group. Three months on, this benefit was still there. The researchers want to try the technique on nightmares linked to post-traumatic stress disorder.

"A large corpus of studies now demonstrates that TMR is both reliable and effective," write Penelope Lewis at Cardiff University, UK, and Daniel Bendor at University College London in a recent paper on the technique.

Although the equipment used in many studies isn't suitable for home use, new devices for a range of dream interventions are now emerging. A leading centre for such research is Pattie Maes's lab at MIT. There, Guillermo Bernal is developing a system called Fascia, which comprises a sleep mask that collects sleep-stage data, plus a linked hub fitted with speakers, lights and an atomiser capable of releasing a variety of scents. A third element of the system collates and analyses signals from the sleeper in real time. The team hopes that Fascia will help people fall asleep faster, as well as improve overall sleep quality and boost memory consolidation.

Also at MIT, Abhinandan Jain is working on a system called Somnia. It electrically stimulates the vestibular system in the inner ear, which tells the brain about the head's position in space. In theory, vestibular stimulation could give dreamers sensations of movement, a bit like the way gamers use virtual reality to get an illusion of motion. It could therefore be used to "rock" someone to sleep without moving them, improving sleep quality and enhancing memory. This is the current focus for Somnia.

## Are you feeling sleepy?

Technology that changes a person's body temperature may also soon find its way into dream engineering devices. Some VR headsets already contain tiny thermoelectric elements that trigger temperature sensations. These might be used to warm a person, helping them to fall asleep, and then cool them to enhance deep sleep. VR also sometimes employs haptic devices to give touch sensations, which the researchers at MIT have used to influence dreams. For instance, a pilot test found that activating an electrical, muscle-stimulating device on the calf during REM sleep led people to report limb-based sensations in their dreams, such as running.

Meanwhile, Haar Horowitz is developing his own sleep engineering wearable, Dormio, along with a method of intervention called targeted dream incubation. Dormio is a glove-like device fitted with sensors that monitor the wearer's heart rate and muscle tone to detect when they have moved into the first stage of sleep. At this point, via a connection to a smartphone or computer, it triggers an audio recording to be played. Five minutes later, a second audio cue wakes the sleeper, who is asked to say what is on their mind, then allowed to fall back into stage-one sleep. This process can be repeated over and over.

Initial research with the device, published in 2020, revealed that audio prompts of the word "tree" reliably led to stage-one, hypnagogic dreams that were related to trees. In 2023, Haar Horowitz, Bob Stickgold at Harvard University

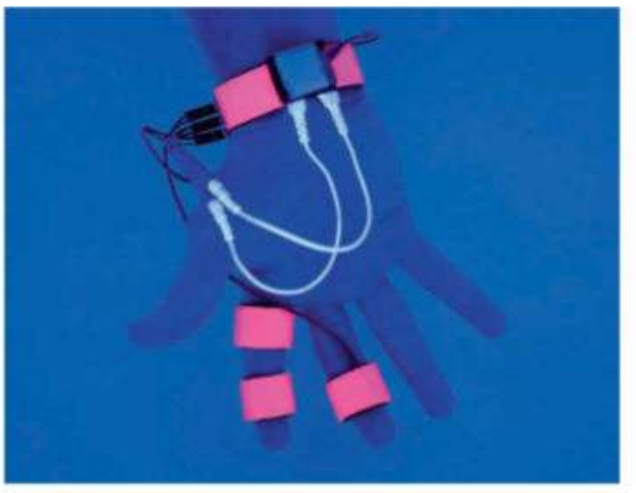
and their colleagues reported a randomised controlled study that went further. As well as triggering tree-themed dreams (one participant remembered having arms made of old wood, for example), the technique also enhanced creative thinking. After 45 minutes of targeted dream incubation, people did better on creativity tests relating to the topic of trees compared with others who had slept without any specific prompt or those who had stayed awake either thinking about trees or simply paying attention to their own thoughts. Psychologists have long sought reliable methods of boosting everyday creativity, and the researchers are excited about the potential of Dormio to do this. "It's a game changer," says Stickgold.

Nevertheless, the idea that we can interact with a sleeping person's brain to influence what they dream about and what they learn has some in the field feeling jittery. In 2018, a team of researchers in China reported that when participants were repeatedly played the name of a familiar snack, such as M&M's, during the stage-two phase of a daytime nap, they awoke feeling more positively about this snack than they did about others that hadn't been named. This effect didn't happen for people who were played the snack names while they were awake.

A few years later, an online advertising campaign by the Molson Coors Beverage Company said it had found that viewers of a specially designed video could be induced to dream about Coors beer. This led to a group of 40 dream researchers, including Stickgold and Haar Horowitz, publishing an online letter in 2021 calling for the regulation of commercial applications of dream manipulation.

*"MANY BUSINESSES ARE VERY CURIOUS ABOUT HOW THEY MIGHT USE DREAM INCUBATION FOR COMMERCIAL GAIN"*

**Dormio, a wearable device that manipulates dreams through sound, has been shown to boost creativity**



LOWER: FLUID INTERFACES GROUP, MIT MEDIA LAB; UPPER: OSCAR ROSELLO

Despite the letter, Haar Horowitz has been approached by numerous businesses curious about how they might use dream incubation for commercial gain. In the meantime, other researchers have more closely examined that route. In 2023, Moran Cerf at Northwestern University published a paper titled "Dream Marketing: A method for marketing communication during sleep and dreams". In it he wrote: "The method allows marketing researchers and practitioners to penetrate the sleeping brain and access the dreamer's thoughts with the goal of impacting subsequent awake behavior." It is this type of potential use that worries many in the field.

The public letter urging caution also mentioned the possibility of nefarious agents targeting another person's dreams to generate feelings of sexual attraction, for example, or to influence political leanings. Asked how exactly it might influence attraction, Stickgold points to the possibility of an app installed on an unwitting owner's phone that might be set to say "sexy Bob" over and over once it has ascertained that the owner has fallen asleep. "Scarier still is [if] it says 'vote Trump'," he adds.

Another concern raised by some is that interfering with our dreams could disrupt the normal beneficial processes that accompany sleep, such as learning and removing detritus from the brain. Maes believes this is one reason why many people aren't already playing foreign vocabulary while they sleep, for example. When it comes to using our sleeping hours, "there are many promising methods out there, but these have not spread because both scientists and the public aren't willing to put their sleep at risk", she says.

Stickgold doesn't share these particular fears. He believes that the degree of control we are currently able to exert over the dreaming state is too small for us to worry about disrupting normal processes. Indeed, despite his other concerns, the future of dream engineering excites him. "I think the potential is real, and it's great," he says. "But the potential for abuse is real too." ▮

Emma Young is a freelance journalist and author based in Sheffield, UK

KLAWE RZECZY

# How to test string theory

String theory seeks to unify physics, but it is often maligned as untestable. Not only is that untrue, it ignores how profoundly useful the idea is, **Joseph Conlon** tells Thomas Lewton

WHEN Joseph Conlon was an undergraduate in the early 2000s, he avoided popular science accounts of string theory because he wanted to engage with it on a technical level, without preconceptions. It was a few years after the "second string theory revolution", when theoretical physicists felt they might be about to crack open the deepest workings of reality, perhaps even deliver a theory of everything. As he explored the maths, Conlon was captivated.

String theory famously suggests that everything is made up of one-dimensional strings (see "String theory: A primer", page 42), and also predicts a huge array of possible universes – some $10^{500}$, for those taking notes. Whatever you think about that, it is fair to say that string theory hasn't generated the testable predictions that many were hoping for. Today, it has a reputation for being untestable, maybe even unscientific. One arch string theory critic dubbed it "not even wrong".

But for Conlon, now a physicist at the University of Oxford, the thrill never faded. String theory remains a potential route to uniting the incompatible ways we think about gravity and the quantum world, he argues, to create a unified theory of quantum gravity. He also claims that his field has been unfairly maligned, and that its detractors are applying double standards. He even insists that string theory does make predictions that we could conceivably probe with upcoming astronomical observations.

Here, Conlon tells *New Scientist* about the enduring joys of string theory, why it is too early to write it off, and why we might need to revise our conception of what makes a useful scientific idea.

**Thomas Lewton: Why do you find string theory so compelling?**

Joseph Conlon: When you start studying it, you realise it is an extremely rich set of ideas and the theory seems to know automatically about many of the incredible structures found in nature. As you construct the theory, you have to try hard to keep it consistent, in other words, to have no internal mathematical contradictions. You find that it keeps on almost failing – you're forced to do things a certain way to avoid those contradictions – but, by a whisker, things work out. It is a Goldilocks calculation. There's a phrase people use to describe this feeling: they call it "string magic".

So, you have been forced towards a theory with a very particular structure. But then you find that the mathematics contains excitations that look very similar to the classes of particles that you find in the standard model of particle physics: "chiral fermions" that are analogous to the electron, or "vector bosons" that are analogous to W and Z bosons of the standard model, and so on. It's like you squeezed through some narrow tunnel and then this enormous cavern opens up that is filled with diamonds.

**That sounds very exciting! Where, then, has the idea come from that string theorists have taken a wrong turn?**

It comes from a human desire to tell certain kinds of stories that have heroes and villains and an ending within quite short timescales. But it isn't reasonable to expect a definitive answer to observational questions on quantum gravity any time soon. The energy scales where theories of quantum gravity, like string theory, are guaranteed to matter are much greater than those which we can access using current technology, such as CERN's Large Hadron Collider. This means it's very hard to say: "Yes, string theory is definitely right, or no, it is definitely wrong."

There's a lot of bad PR around the testing of string theory. There was no possible way to tell that atoms existed for most of human history – that didn't mean that the idea of atoms was wrong. Theoretical physics is hard and things can take a long time.

**One criticism levelled at string theory is that it describes every universe except our own. The space-time of our universe has a slight positive curvature, but string theory only describes universes with negative curvature. Isn't this quite a problem?**

The small, positive curvature of our universe comes about because of the small, positive energy contained in the vacuum of space. This is what is commonly known as dark energy. And, look, dark energy is the biggest open problem in physics. Attempts at theoretical calculations of this "vacuum energy" encounter quantum corrections, created by particles popping in and out of existence in the vacuum, that are vastly ›

## STRING THEORY: A primer

**String theory is a leading candidate for a "theory of everything", because it promises to unite quantum mechanics and general relativity, the two main pillars of modern physics, into a unified theory of quantum gravity. It says that everything is made of tiny strings, whose vibrations produce effects that we interpret as particles. For that to work, string theory also posits that we live in a universe with 10 dimensions or more, most of them curled up so tightly that we don't notice them.**

**The idea had its genesis in the late 1960s, when Gabriele Veneziano, at the time a visiting theorist at the CERN particle physics laboratory near Geneva, Switzerland, realised this mathematical framework may describe the strong nuclear force, one of the four forces of nature. Troublesome anomalies thwarted his work initially, but over the following decades, many theorists became convinced that string theory depicts physical reality.**

**During the "first string theory revolution" in the mid-1980s, those troublesome anomalies were eliminated and it became clear that the theory contains all you need to describe the fundamental particles. Plus, physicists alighted on a nifty way to spool up string theory's many dimensions so that it resembled our four-dimensional reality.**

**Then, as part of the "second string theory revolution" in the mid-1990s, Juan Maldacena at the Institute for Advanced Study in Princeton, New Jersey, discovered a kind of Rosetta Stone within string theory. It allowed lower-dimensional quantum descriptions of reality to be projected into higher-dimensional models of quantum gravity. It is highly technical stuff, but it provided a long-sought link between the ostensibly separate theories of gravity and the quantum world. The AdS/CFT correspondence, as Maldacena's discovery is called, created shock waves among physicists – and it suggested that our universe was a giant hologram.**

**The only trouble is that the "AdS" part, which stands for anti-de Sitter space, means that string theory only works for universes with a special kind of curvature, which is different to the one we observe around us. String theorists see this as a minor wrinkle to be ironed out. But the problem has persisted for two decades, leading some physicists to feel the whole string theory project has got itself into an unpickable knot.** TL

larger than the observed value. So, indeed, string theory does not get this right, but, currently, there are no good solutions to this problem outside of string theory either.

However, string theory has given strikingly precise and surprising descriptions of quantum gravity in spaces with negative vacuum energy. This happens through what is called the AdS/CFT correspondence. One insight that has emerged from this is that quantum gravity theory in, say, five dimensions can be identical to non-gravitational quantum theories in four dimensions. While negative vacuum energy is not something we see in our universe, to me, the depth of these results gives confidence in the underlying robustness of the theory.

> "It's like squeezing through a tunnel into a cavern filled with diamonds"

**What about the idea that string theory contains a near-infinite number of possible solutions and so is, again, detached from reality?**
There are also an infinite number of solutions in general relativity and an infinite number of quantum field theories. The number of solutions is not a problem in itself, so long as the solutions that apply to our universe can be homed in on by comparing them to the world around us. The difficult thing with string theory – and other approaches to quantum gravity – is how to constrain potential solutions with observations. It is hard to make discriminating measurements, as the places where the theory becomes most relevant are at such incredibly high energies.

**So how can we test string theory?**
There are different kinds of connection between string theory and observables in physics. For instance, there are things which would be wonderful if true, which are probably not true, but which you could get lucky on. Let me give you an example: cosmic strings are these hypothetical, extremely long threads of pure energy that travel close to the speed of light. One outside possibility is that these cosmic strings are really fundamental string theory strings. They could potentially be observed, because they would have the effect of warping space-time and deforming light coming to us from distant galaxies, so that we would see a kind of double image.

**That sounds like a long shot...**
There's something else too. String theory is a 10-dimensional theory, which means, if it is true, there really are extra spatial dimensions compared to the three we know of. But if we can't see them, where are they? An analogy that I find useful here is if you imagine trying to knit wearing boxing gloves. You can't knit because the scale you're trying to do stuff on is far smaller than what you're sensitive to while wearing those huge gloves. But that doesn't mean knitting is impossible.

What this means is that string theory's extra dimensions must be what we call "compactified", in other words, screwed up so small that we can't detect them. Here's where we get to the core of the matter. When you do this mathematically, you find that a legacy is the existence of particles called moduli, which have properties that are characteristic of the size and shape of the extra dimensions. Moduli are particularly interesting in the context of

NANOGRAV

**The Very Large Array radio telescopes in New Mexico are being used to detect signatures of gravitational waves**

cosmology because they live a very long time and so tend to hang around, and so potentially can give observable signatures.

**Are you saying we could search for moduli?**
Yes, they are an example of something we could, in principle and with some luck, find. It seems that moduli would have been produced in the very first fraction of a second after the big bang, and because they only interact through gravity, they would have survived in larger numbers for a short while compared to other kinds of particles. For a fraction of a second, the energy of the universe would primarily be in the form of moduli, which are characteristically stringy in origin. This is one area where we can have a conversation about stringy ideas of the early universe and how they relate to observations.

**Can we see back far enough in time to look for these telltale particles?**
Not yet, but there is hope. The context here is that we know very little about what the universe was like immediately after the big bang up until the point when the first nuclei were made, not even how much of the universe was composed of matter and how much was radiation. However, string models of cosmology strongly suggest something different at this time compared to standard cosmology, as the two frameworks predict different "equations of state". With my colleagues, I recently published a paper where we try to work out what the stringy alternative histories would be.

In principle, gravitational waves offer a chance of mapping this period. They pass through everything and so can emanate from a sliver of a fraction of a second after the big bang. These very ancient beasts are called primordial gravitational waves and they are one explanation for the recently discovered background hum of gravitational waves. The way in which the size of this background changes according to the length of gravitational waves observed can tell you about what the equation of state of the universe is. With future observations, we might be able to look at the gravitational wave spectrum and tell if there was a long, matter-dominated spectrum early in the universe which then transitioned into radiation. Technology for detecting gravitational waves is rapidly advancing: for example, the recent observations using pulsar timing arrays by the North American Nanohertz Observatory for Gravitational Waves.

**If you saw this signature, would it be solid proof of string theory?**
All you could strictly say is that you have domination by matter particles that behave like moduli. That doesn't tell you, for certain, that these particles are originating in extra-dimensional string compactification. I prefer to think of it as string theory motivating certain scenarios which can be tested in the way that you do ordinary science. But even if moduli particles are found to exist, that wouldn't establish string theory as the one true theory of the universe.

By the way, the same is true of another type of particle that often arises in string theory called the axion. Even if we established that multiple kinds of axions exist, that would not prove string theory is true.

**What if you had many different kinds of observations – cosmic strings, moduli, axions – all pointing towards string theory from different directions?**
If it starts going "quack, quack, quack", and it walks on land, and it floats in water, then you start to think, well, it might be a duck.

**Is there anything that would make you give up on string theory?**
Not while it remains a wonderful motivator of ideas which you might not otherwise think about. String theory has given so much to all the areas around the particular question of how you combine quantum mechanics and gravity. For example, if you care about understanding quantum field theories or mathematics or cosmology or particle physics – far removed from the realm of quantum gravity – string theory has answers for you. A lot of the rivals to string theory do not have that much engagement with other areas of theoretical physics beyond quantum gravity.

**Do you believe there is a single unifying structure underneath all those areas of theoretical physics?**
The standard model of particle physics is clearly structured. For example, the particles come in these sets of three that we call generations. There's something underlying this; the standard model is not the final story. And I think if you're serious about where the good ideas are for finding out what the final story is, then the route passes through string theory. ▮

Thomas Lewton is a features editor at *New Scientist*

# The back pages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## Mathematics of life

# Fitting it all together

Maths tells us the best way to cover a surface with copies of a shape – even when it comes to jigsaw puzzles, says **Katie Steckles**

Katie Steckles is a mathematician, lecturer, YouTuber and author based in Manchester, UK. She is also puzzle adviser for *New Scientist*'s weekly puzzle, BrainTwister. Follow her @stecks


*Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations. It appears monthly.*

**Next week**
Debunking gardening myths

WHAT do a bathroom wall, a honeycomb and a jigsaw puzzle have in common? Obviously, the answer is mathematics.

If you are trying to cover a surface with copies of a shape – say, for example, you are tiling a bathroom – you ideally want a shape like a square or rectangle. They will cover the whole surface with no gaps, which is why these boring shapes get used as wall tiles so often.

But if your shapes don't fit together exactly, you can still try to get the best coverage possible by arranging them in an efficient way.

Imagine trying to cover a surface with circular coins. The roundness of the circles means there will be gaps between them. For example, we could use a square grid, placing the coins on the intersections. This will cover about 78.5 per cent of the area.

But this isn't the most efficient way: in 1773, mathematician Joseph-Louis Lagrange showed that the optimal arrangement of circles involves a hexagonal grid, like the cells in a regular honeycomb – neat rows where each circle sits nestled between the two below it.

In this situation, the circles will cover around 90.7 per cent of the space, which is the best you can achieve with this shape. If you ever need to cover a surface with same-size circles, or pack identical round things into a tray, the hexagon arrangement is the way to go.

But this isn't just useful knowledge if you are a bee:

DARIUSZ SZWANGRUBER/ALAMY

a recent research paper used this hexagonal arrangement to figure out the optimal size table for working a jigsaw puzzle. The researchers calculated how much space would be needed to lay out the pieces of an unsolved jigsaw puzzle, relative to the solved version. Puzzle pieces aren't circular, but they can be in any orientation and the tabs sticking out stop them from moving closer together, so each takes up a theoretically circular space on the table.

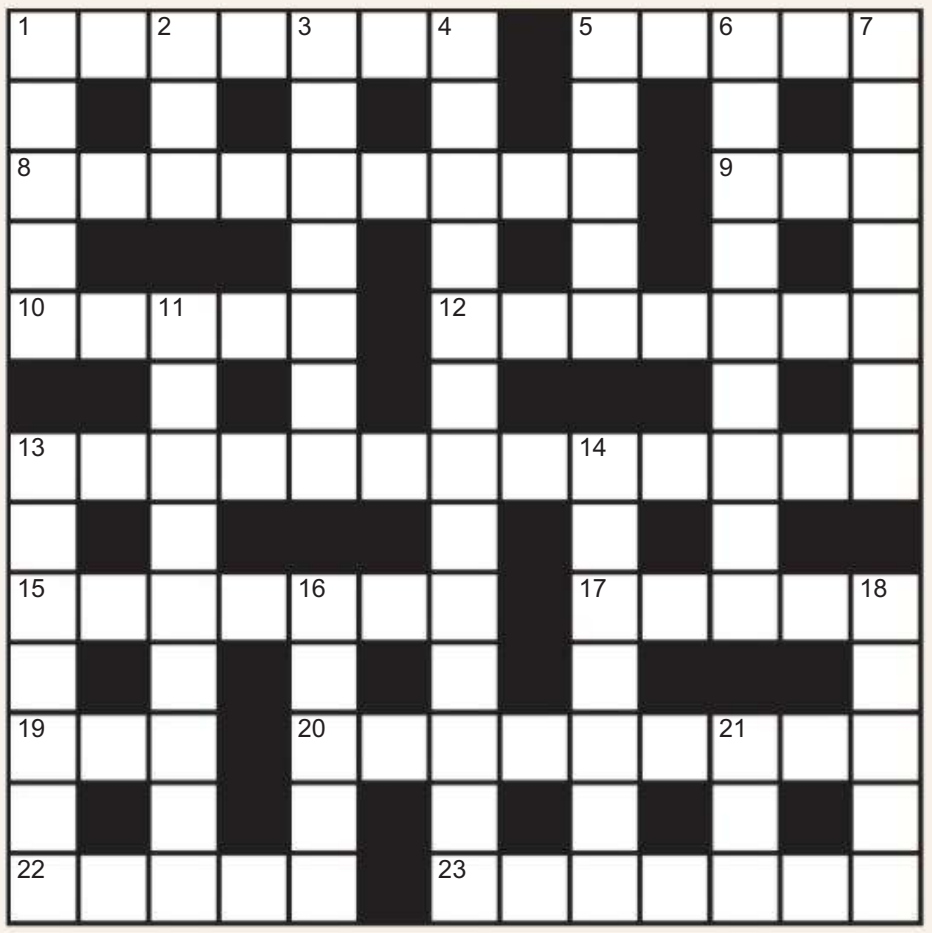
By comparing the size of the central rectangular section of the jigsaw piece to the area it would take up in the hexagonal arrangement, the paper concluded that an unsolved puzzle takes up around 1.73 times as much space.

This is the square root of three ($\sqrt{3}$), a number with close connections to the regular hexagon – one with a side length of 1 will have a height of $\sqrt{3}$. Consequently, there is also a $\sqrt{3}$ in the formula for the hexagon's area, which is $3/2 \times \sqrt{3} \times s^2$, where s is the length of a side. This is partly why it pops out, after some fortuitous cancellation, as the answer here.

So if you know the dimensions of a completed jigsaw puzzle, you can figure out what size table you need to lay out all the pieces: multiply the width and height, then multiply that by 1.73. For this ingenious insight, we can thank the bees. ▮

**These articles are posted each week at newscientist.com/maker**

## Cryptic crossword #129 *Set by Trurl*



**Scribble zone**

Answers and the next quick crossword next week

**ACROSS**

**1** Rounds nickel with a caustic substance (7)
**5** Perhaps Sam's tricky clue, without number (5)
**8** Racing driver's speed (horizontal) (9)
**9** Sounds like everyone's a boring tool (3)
**10** Imago, developed, is Mexican's friend (5)
**12** First pair jettisoned from ship's extension – it could start something (7)
**13** Morally clear-cut, like an old movie (5-3-5)
**15** Earth is eaten away round the edges by rats and mice (7)
**17** Half-heartedly shout: "It's underneath!" (5)
**19** Tree remains (3)
**20** Philosopher seeing total rise in entropy (9)
**22** 9 almost getting approval for German whiz (5)
**23** Poetic player even I can mostly love (to begin with) (7)

**DOWN**

**1** Dominant peak over unit of land (5)
**2** Noise of lower satellite losing rear end (3)
**3** Twit seizing 2 connected computers (7)
**4** In jam, provided by a distant stall, after maceration (2,1,10)
**5** Reproductive parts – cute, right? Not entirely! (5)
**6** Blacken name of king, but cut short question (9)
**7** Grow green movement, including the French (7)
**11** Distressed fan whined, generating speculation about uncertain outcome (2,3,4)
**13** You buy it cheaply, but profit (7)
**14** Lexicographer's spider, possibly? (7)
**16** Extremely noisy, in the manner of an African mammal (5)
**18** Gleeful cry of one going fast on carousel, finally getting turn (5)
**21** Twitch delivering second half of strategy (3)

**Our crosswords are now solvable online**
newscientist.com/crosswords

## Quick quiz #239
*set by Bethan Ackerley*

**1** What name is given to the retention of juvenile features in adult animals?

**2** Enterochromaffin cells are sometimes also called what, after their discoverer?

**3** In which country were the oldest known stone tools found?

**4** The fluid in the cavities of your elbow and hip joints is known as what?

**5** Frank Wilczek and Steven Weinberg are together associated with which hypothetical elementary particle?

*Answers on page 47*

## BrainTwister
*set by Peter Rowlett*
### #7 Home primes

**To find the home prime of a number, follow this procedure: first, find its prime factors; then concatenate these by writing the prime factors in size order to form a new number using all of their digits; then repeat until the resulting number is prime.**

**For example, 9 = 3 × 3, so its prime factors are 3 and 3. These concatenate to give 33. Now, find the prime factors of 33. They are 3 and 11, which concatenate to give 311. Since 311 is prime, we stop and say that the home prime of 9 is 311.**

**The home prime of a prime number is the number itself. So, for example, the home prime of 2 is 2.**

**What is the home prime of 6?**

**How about the home prime of 10?**

**Which number less than 20 has a home prime of 1129?**

*Solution next week*

## Weighty matter

**How heavy is Earth and how much weight could it sustain before caving in?**

***Herman D'Hondt***
*Mascot, Australia*
Let's start by realising that there is a difference between mass and weight. Mass is an inherent property of things and reflects how much "stuff" there is in something. Weight, on the other hand, is the force an object feels under the influence of gravity.

Thanks to Albert Einstein's insights, we now know that gravity is equivalent to acceleration, so an accelerated mass will experience weight because of that. Mass is expressed in kilograms, weight in newtons (N), or kg × m/s$^2$. The acceleration caused by Earth's gravity is 1 *g*, or about 9.8 m/s$^2$, giving a 75-kilogram person a weight of 735 N. Under an acceleration of 2 *g*, the same person would weigh 1470 N.

The total mass of Earth is approximately 6 × 10$^{24}$ kg.

**"If Earth is compressed to the size of a marble, the pressure overcomes the nuclear forces, creating an Earth-mass black hole"**

Under normal conditions, adding more mass to it won't significantly affect it. However, under extreme conditions, it can be made to collapse, by either adding enough mass, or compressing it enough.

In the 1930s, Subrahmanyan Chandrasekhar calculated that, if an object becomes heavier than about 1.4 times the mass of the sun, the pressure caused by gravity becomes stronger than the nuclear forces that prevent atoms from collapsing.

Any object more massive than that will become a black hole, as will Earth if about 460,000 Earths (2.8 × 10$^{30}$ kg) are piled on top of each other.

Alternatively, if Earth is compressed to about the size of a marble, the pressure overcomes the nuclear forces and, again, we have created an Earth-mass black hole. I will leave the design of the pressurising system as an exercise for the student.

***Eric Kvaalen***
*Les-Essarts-le-Roi, France*
Earth has a mass of about 6 million million million million kilograms.

If more mass were added to it, it would at first get bigger. But the pressure in the deep interior would get higher and higher, and this would compress the material (rock or metal core). Eventually, it would reach the point where Earth would no longer get bigger as one adds mass, it would just have a higher and higher average density. After this, adding mass would actually cause Earth to shrink. This is seen in white dwarf stars – the more massive they are, the smaller they are. But the shrinkage would take place gradually as more mass is added. Earth wouldn't yet collapse.

As more mass was added, Earth would pass the Chandrasekhar limit of 1.4 solar masses, at which point the electrons in the deep parts of the planet would combine with the protons, forming neutrons. This would be a collapse, forming something similar to a neutron star.

***Mike Follows***
*Sutton Coldfield, West Midlands, UK*
The mass of Earth is about 6 × 10$^{24}$ kilograms. Its weight depends on the local gravitational field strength, which is about 6 millinewtons per kg, due mainly to the gravitational pull of the sun. This gives it a weight just shy of 4 × 10$^{22}$ N.

Increasing its mass might eventually turn Earth into a star. However, a star normally starts by fusing hydrogen in its core, before "burning" progressively heavier elements. But the core of an "Earth star" would be composed of heavier elements like carbon, oxygen, silicon and iron.

If extra mass were added in the form of hydrogen, any hydrogen fusion would need to take place in a shell surrounding this core. Iron can't undergo fusion, but the other elements could fuse if sufficient mass were added to make the core hot enough. Perhaps as you read this there is a planet out there that is capturing hydrogen gas blown into its gravitational well by a local supernova.

***Hillary Shaw***
*Newport, Shropshire, UK*
Subsiding would be a better descriptor than "caving in". Some 40 kilometres below us, the planet is no longer solid but a viscous magma. Very viscous – about 10,000 to 100 million times the viscosity of water. If you started piling space rocks at one point on our crust, the land would slowly subside, at around 1 metre for every 2.5 metres height of rocks you piled up. Adjustment would take millennia, as we see in the Baltic Sea region today, where the land is still rising after the ice cover disappeared thousands of years ago.

If you could pile, say, a 100-kilometre-high rock tower, measuring 10 metres on each side (and keep it balanced upright), it would, in short order, sink down until it reached magmatic regions, under enormous pressure. Then it might come right back up again, accompanied by lava and gases.

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Why is it that some (lucky) people can sleep through just about anything?

## This week's new questions

**Wake up, sleepyhead** **Why are some people very heavy sleepers, while others are woken by only a small disturbance?** ***Rachel Mckeown****, Cambridge, UK*

**Going grey** **Why is it that our hair – and for men, our beard – goes white while the other hair on our head (eyebrows and eyelashes) stays its original colour?** ***Guy Cox****, Sydney, Australia*

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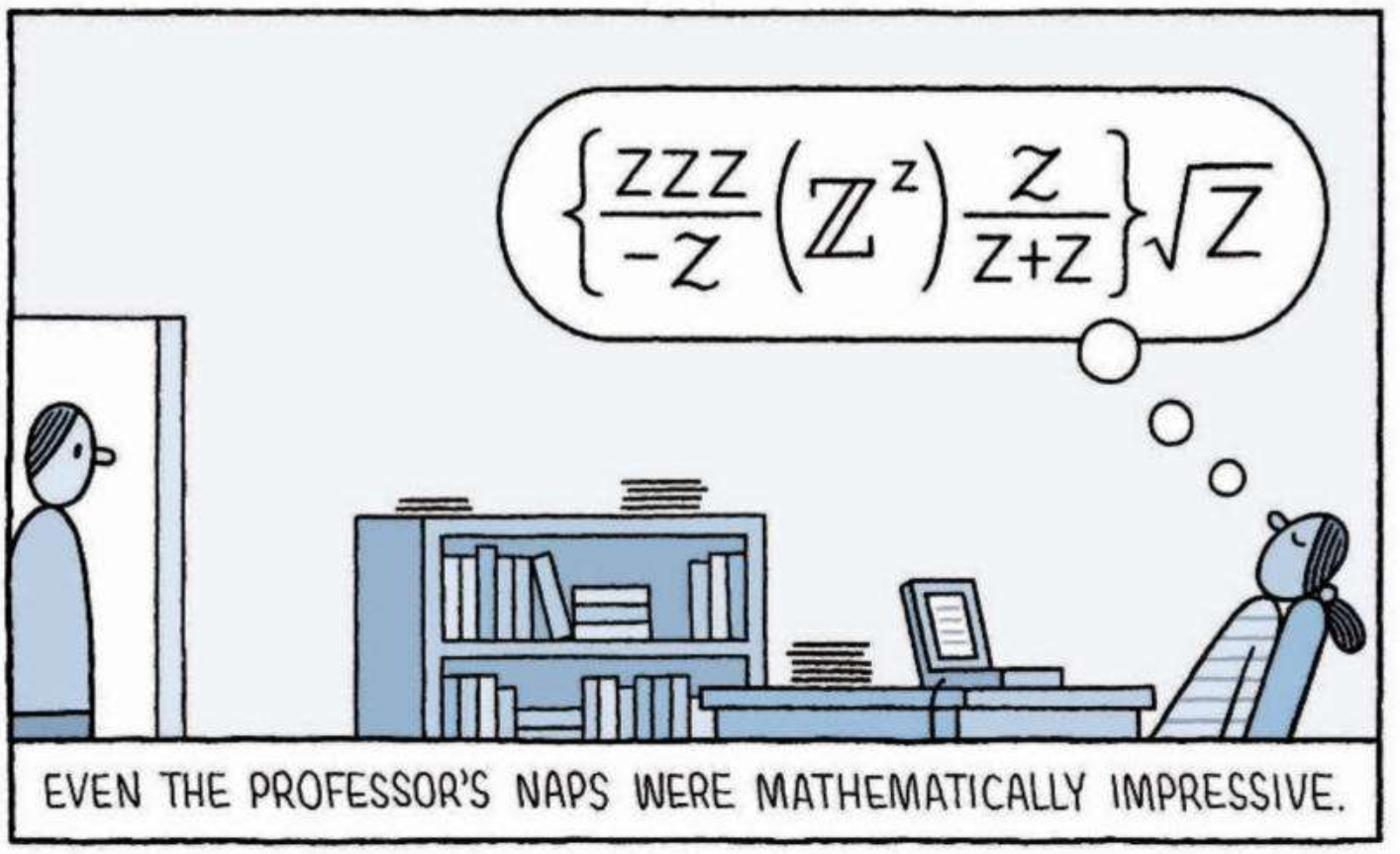
**Tom Gauld**
*for New Scientist*




I hope you took out volcano damage insurance for the area you did this experiment in.

## Breaking in

**Given the number of cars on the roads now, what are the chances of my remote key fob unlocking another car (and vice versa)?**

***Trevor Campbell***
*Berrima, Australia*
None. Modern cars use an encrypted rolling number system. While I don't know the length of the cryptographic keys actually used, even short keys by today's standards, say 512 bits, give an astronomically large number of actual key possibilities.

Furthermore, each key press transmits a completely different code – this means that a hacker can't use a recording device to capture the code when the owner presses the fob and then replay it at a later time to unlock the vehicle.

The systems used today are also tolerant of missing numbers in the sequence, so if the last number used was 843, then the car would expect 844 as the next valid one, but will actually allow 845, 846, and so on, for some reasonably large sequence of numbers, so you don't have a problem if you press the fob when not in range. Modern cars usually track two individual key fobs separately. All this complexity is why it is so expensive to replace keys when they are lost.

**"Fifty years ago, my car key also opened my filing cabinet. It was convenient, but gave me little confidence in the security of either"**

***Helen Taylor***
*Ferryhill, Durham, UK*
Back in the day, I had a remote fob that, when I was in a car park and remote-locked my car, would unlock several other cars. I would unlock it again and they would lock.

I would give up and use the key to lock my car because most people had nicer vehicles than my old Nissan coupe.

***Peter Cowley***
*Quarndon, Derbyshire, UK*
Over 50 years ago, when I was a research student with an old Mini Cooper, my car key also opened my Roneo Vickers filing cabinet and vice versa. It was convenient, but gave me little confidence in the security of either.

I also unlocked and climbed into the wrong Mini once, only realising my mistake by the unusual tidiness of the interior.

## Too cute

**Why do we say "aww" when we see small, fluffy things? (continued)**

***Mike Tongue***
*Newark upon Trent, Nottinghamshire, UK*
I have always thought that we find baby animals attractive in order to reduce our temptation to eat them before they have got to an economic size. ▮

## Answers

### Quick quiz #239 *Answers*

**1** Neoteny
**2** Kulchitsky cells, after Nikolai Kulchitsky
**3** Kenya, at the Lomekwi site
**4** Synovial fluid, or synovia
**5** The axion

### Quick crossword #151 *Answers*

**ACROSS 1** Beaufort, **5** G-force, **9** Recharge, **10** Prozac, **12** Urine, **13** *Lost World*, **14** Q fever, **16** Surgeon, **19** Sixteen, **21** Siskin, **23** Expansion, **25** Brent, **26** Toroid, **27** Off-ramps, **28** Stereo, **29** Hypnosis

**DOWN 1** Barium, **2** Arctic fox, **3** Flame, **4** Regular, **6** Fireworks, **7** Razor, **8** Encoding, **11** Isms, **15** Vee engine, **17** Epidermis, **18** Asbestos, **20** Nail, **21** Sandfly, **22** Stasis, **24** Purge, **25** Boron

### #6 Factor factory *Solution*

The factors of 8 are 1, 2, 4 and 8, of which three-quarters are even.

There are 25 numbers between 1 and 100 whose factors are half odd and half even. These are all the numbers that are divisible by 2 but not divisible by 4.

For factors that are divisible by 3, you need the number itself to be divisible by 3. But in that case, at least half of its factors will be divisible by 3 (this is true because for every factor d not divisible by 3, the number 3d will also be a factor), so the answer is zero.

## On the other hand

It is maybe the most politically insightful psychology study published in the past 60 years. And it is maybe not.

The study in question is "State resident handedness, ideology, and political party preference: U.S. presidential election outcomes over the past 60 years".

Its author, Stewart J. H. McCann, professor emeritus of psychology at Cape Breton University, Canada, pored over data about US (rather than Canadian) voters during the years 1964 to 2016. He found, he says, a striking pattern: "Higher state levels of left-handedness were associated significantly with liberal ideology."

What does this mean? McCann distils the answer into a 46-word sentence that grows more meaningful each dozen times you read it. Or less meaningful.

That sentence is: "It is speculated that such relations are grounded in hypothesized but poorly understood genetic links between handedness, personality, and political beliefs and attitudes, and, that a foundational *genetic predisposition* to left-handedness in a population may have much greater impact on correlates than *overt* levels of left-handedness."

Feedback notes that in those 46 words, and in the entire paper, much is left to the imagination.

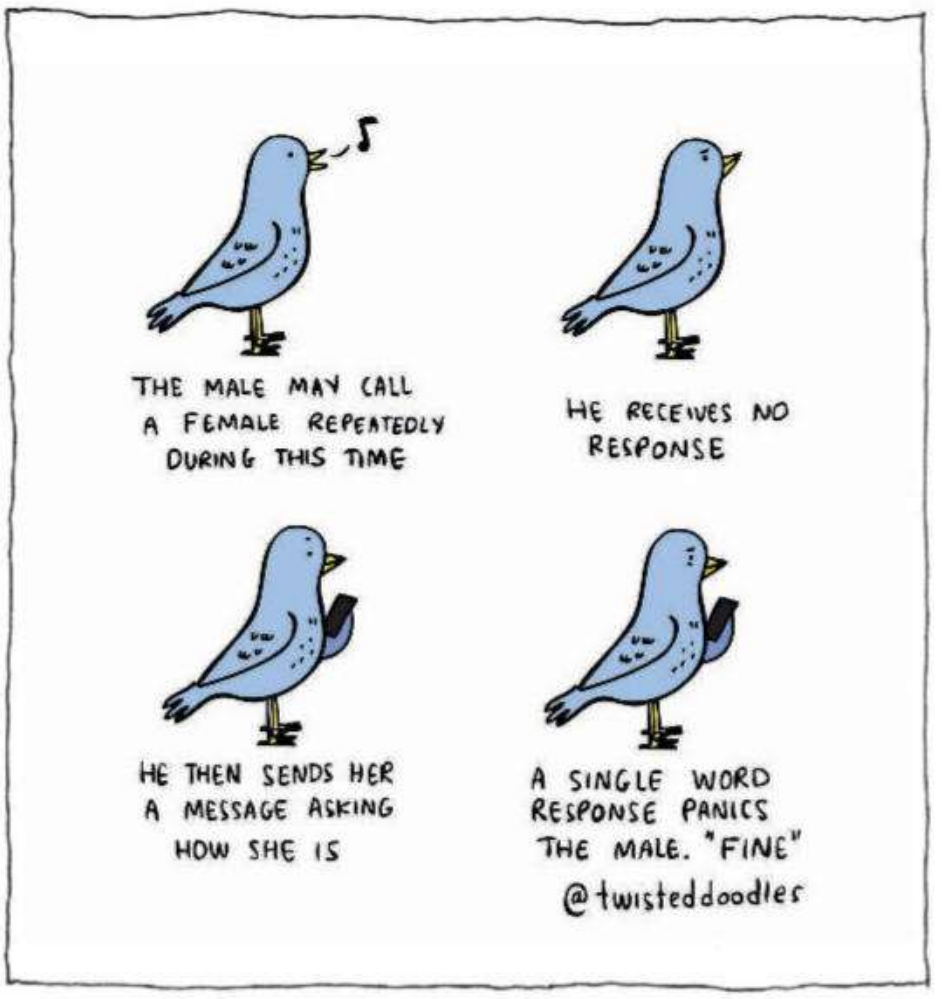
## In solitary splendour

One's personality can shine forth when one is alone rather than with companions.

That is the big reveal in a study called "Temperament behaviours in individually tested sheep are not related to behaviours expressed in the presence of conspecifics".

In particular, say the researchers at the University of Melbourne, Australia, and the University of Edinburgh, UK: "Vocalisations were rarely performed when other sheep were present, suggesting that this behaviour is a response to being alone."

## Twisteddoodles *for New Scientist*


THE MALE MAY CALL A FEMALE REPEATEDLY DURING THIS TIME
HE RECEIVES NO RESPONSE
HE THEN SENDS HER A MESSAGE ASKING HOW SHE IS
A SINGLE WORD RESPONSE PANICS THE MALE. "FINE"
@twisteddoodles

### Got a story for Feedback?

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**Consideration of items sent in the post will be delayed**

## When nothing is good

James Hodges writes: "In response to your segment on doctors waiting for patients to get better by themselves: it is absolutely totally a part of our job.

"I am a paediatrician. We take doing nothing very seriously. 'Cat-like observation and masterful inactivity' is a firmly held mantra in our world. We often admit patients for viral illnesses for which there is no treatment. We watch, we support, and the child gets better.

"There are times when doing nothing is positively the best treatment. When you have an unstable child who is pretty sick they will deteriorate if they get agitated. We will often prescribe 'minimal handling', which is an assertive way of saying leave the kid alone. Let them sleep, hopefully in with a parent, and don't bother them too much. Definitely don't go forcing needles or medicines on them. Experienced paediatric nurses are absolutely brilliant at this (very much art of medicine).

"This is not just in acutely unwell children. Colicky babies will not become colicky adolescents (mostly). There are an absolute myriad of paediatric conditions we don't treat – idiopathic thrombocytopenic purpura is a great example. There is plenty where we do treat, but the evidence that we change anything with that is pretty minimal.

"Children's physiology is truly awesome and I often feel like a passenger, watching them fix themselves, and occasionally adding some reassurance and distraction. It's a pretty great job."

(Feedback notes that – this letter being an exception – nearly all the responses we have received about this question have been from doctors who are retired.)

## As fresh as onions

Dimple Devi and her colleagues have devised a way to use onions to prolong the freshness of milk.

The researchers, based at the Central Institute of Technology Kokrajhar, India, discuss it in a report called "Onion peel extract as milk freshness indicator in biopolymer-based intelligent packaging films", published in the journal *Food and Humanity*. If the milk goes bad, the onionified packaging film changes from light pink to colourless to brown.

Utilised this way, the researchers say, onion does almost no end of good things: "The addition of onion peel extract in the biopolymers reduced moisture content, water solubility, swelling index, and transparency, and significantly increased antioxidant activity, and total phenolic content." It also "utilized a common and abundantly generated agricultural / food processing waste".

The report doesn't address the question of how consumers might react to the idea of milk protected by – though not flavoured with! – onion.

## Carry on carrying

Perusing Feedback's growing list of trivial superpowers, Ken Taylor poses a question about his own ability: "Here's a trivial superpower I only just realised I had... the ability to carry lots of glass containers. As a teenager, I delivered milk and could manage six full pint bottles of milk and 10 empties. As an adult, I could impress friends by carrying four full pints of beer (the ones without handles) by splaying my fingers wide and curling them round the rims. Looks very cool, unless you drop them. Does this rate as a superpower? Your call."

Ken's calm persistence in carrying containers exemplifies the tradition of "carry on". ▮

*Marc Abrahams*

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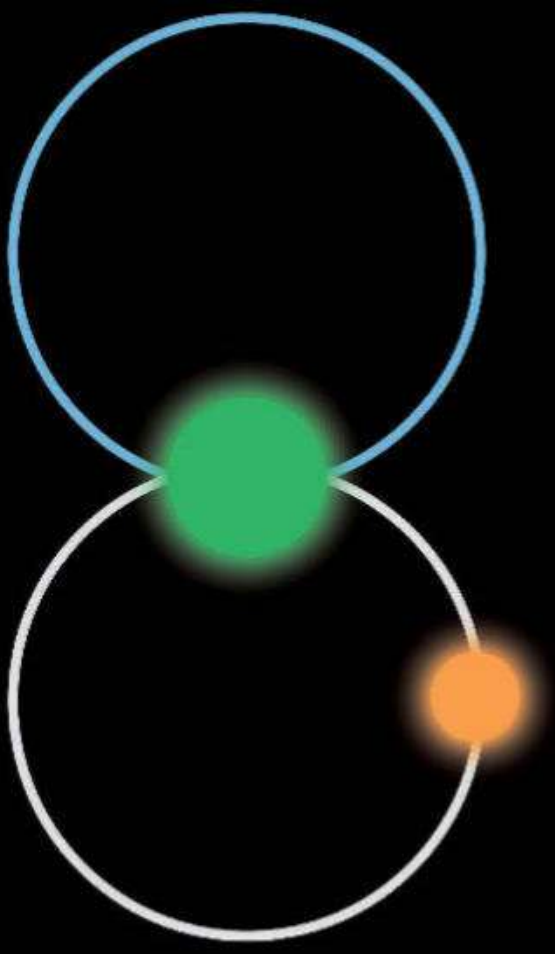

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